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WT-73 (SAN)

OPERATION GREENHOUSE

SCIENTIFIC DIRECTOR'S REPORT

ANNEX 9.2

SANDIA CORPORATION PROVING GROUND GROUP

PART II—MECHANICAL ASSEMBLY

NUCLEAR EXPLOSIONS

1951, Sanitized Version

[redacted]

Defense Threat Reduction Agency
8725 John J Kingman Road MS 6201
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TDANP/TRC 17 May 2001

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Scientific Director's Report of Atomic Weapon Tests at Eniwetok, 1951

Annex 9.2

Sandia Corporation Proving Ground Group
Part II — Mechanical Assembly

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SANDIA CORPORATION
PROVING GROUND GROUP

Part II — Mechanical Assembly

by

ROBERT A. KNAPP

and

TASK UNIT 3.1.4.2 PERSONNEL

Sandia Corporation Proving Ground
Ordnance Department

Approved by: R. W. HENDERSON
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Albuquerque, New Mexico

August 1951

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Acknowledgments

The preparation of this report was accomplished with the assistance of the following persons: R. H. Schultz, who compiled [redacted] sections as well as a portion of the general text; R. T. Bush, who was responsible for design and who reported on the Handling Equipment phase; and J. R. Heaston, who reported on [redacted] and Rear Area Training. The Photographic Organization, Task Unit 3.1.4.6, provided all photographs for the report.

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TABLE

CHAPTER 2 ORGANIZATION, WEAPONS PLANS, AND TRAINING AT REAR AREA

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[redacted]

Abstract

The activities of the Mechanical Assembly Unit, TU 3.1.4.2, are summarized in this report. This group prepared the experimental nuclear weapons and delivered them to a predetermined zero point, which was the focal point for all the instrumentation involved in Operation Greenhouse.

The Rear Area portion of this report is essentially concerned with group organization, supply, and training. The Forward Area operations discuss the actual assembly work aboard the laboratory ship, USS Curtiss (AV-4), the weapon delivery to the zero towers, and final positioning and assembly in the tower cabs. This report includes, in Sec. 3.3.2 and Appendix A, bomb assembly and delivery schedules and sample check sheets comprising a weapons technical inspection data book (also known as "bomb book") and a shipping manifest listing tools, equipment, and supplies.

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Chapter 1

Introduction

The mission assigned to the Mechanical Weapons Assembly Unit was the assembly of four experimental weapons aboard the laboratory assembly ship and the delivery of these weapons from the ship to the firing positions atop specially constructed 200- and 300-ft towers on designated islands of Eniwetok Atoll, where final nuclear insertion and assembly was performed.

The detailed description of procedures and techniques for the [redacted] and Booster weapons is not included in this report. Since the information and procedures given in the bomb books for these weapons and [redacted] is repetitious, assembly and delivery schedules for the latter bomb only have been included in the body of the report. Because these operations for the [redacted] weapon were more complex, however, a sample weapons technical inspection data book consisting of assembly and delivery check sheets and schedules has been included as Appendix A.

[redacted]

[redacted]

Chapter 2

Organization, Weapons Plans, and Training at Rear Area

2.1 ORGANIZATION AND PERSONNEL

The mechanical assembly organization for Operation Greenhouse was composed of six Sandia Corporation and three Los Alamos employees. Each person was carefully selected for his job to obtain maximum technical talent with the result that the group acquired personnel experienced in this field of endeavor. The Los Alamos specialists performed high-explosive (HE) inspection and installed and tested the detonators. George Hess acted as the GMX Division consultant on matters pertaining to [redacted] The Sandia Corporation employees possessed diversified backgrounds which were essential for successful completion of the operation with a minimum of personnel. The personnel assignments were as follows: division head and bomb supervisor, R. A. Knapp; tower supervisor, R. H. Schultz; bomb delivery supervisors, R. T. Bush (returned to Sandia April 8 because of an emergency requiring his presence at home) and I. D. Hamilton; machinist, S. A. McCollum; mechanical assembly supervisors, J. R. Heaston, How''; G. K. Hess, Cylinder; R. H. Schultz, TX-5 and Booster; detonator specialist, W. H. Meyers; and HE specialist, P. E, Leake.

2.2 WEAPON DATA

The experimental weapons fired during Operation Greenhouse fall into three categories: [redacted] Table 2.1 contains a summary of facts pertaining to the weapons detonated and the supply carried aboard the weapons assembly ship. Each of these weapons will be described in more detail later in this chapter.

2.2.1 [redacted]

[redacted] These improvements are included in reports by GMX Division, W Division, and the [redacted] Steering Committee; therefore only a brief description of the components will be included here.

The outside diameter of the HE sphere was [redacted] These charges were machined on all surfaces and then glued together around the pit. A few of the photographs showing the assembly fixture and progressive steps taken in the R-site assembly building at Los Alamos are included in this report as Figs. 2.2 to 2.8.

[redacted]

[redacted]

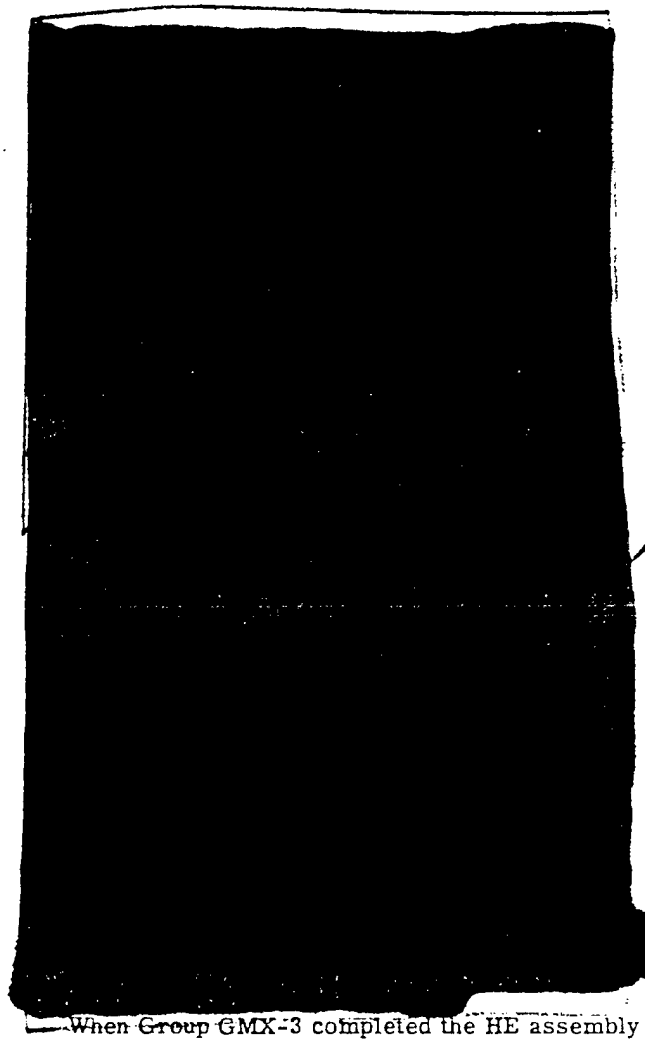
TABLE 2.1 WEAPON COMPARISON DATA

Unit	Quantity of HE Units	Quantity of Inert Units	Detonator Type	HE Lens System	Tower Height (ft)	Shot Island	Shot Date	Number of Dry Runs*	Type of X-unit
[redacted]	2	1	1E20	[redacted]	300	Runit	Apr. 8	4	[redacted]
	1	1	1E22		300	Engebi	Apr. 21	4	
	2	0	1E22		200	Engebi	May 25	2	
	2	1	1E22		200	Eberiru	May 9	3	

* The dry runs listed include X-day rehearsals.

[redacted]

[redacted]

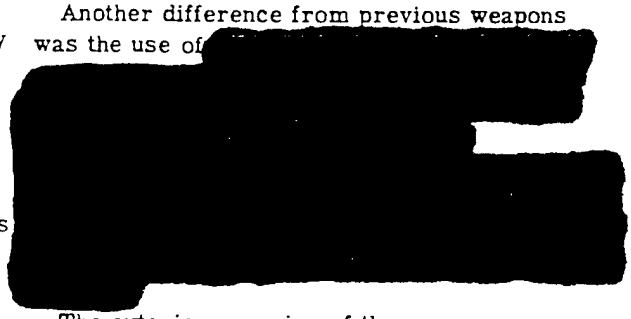


When Group GMX-3 completed the HE assembly at R-site, the lightweight sheet-metal sphere cases were not available; therefore these assemblies were shipped to Sandia in the heavy cast aluminum space chambers used by Los Alamos for test shots. At Sandia's Area No. 2 these units were transferred from the heavy to the light cases as soon as the first four preproduction items had been delivered by Douglas Aircraft Corporation (see Fig. 2.11). It was discovered that some of the hole locations for detonators were not properly spaced (Fig. 2.12), and it was necessary to enlarge the offset holes to eliminate interference from the raised detonator pads.

Type 1E22 detonators were used on this unit. [redacted] For details of design and performance, consult reports published by GMX Division of the Los Alamos Scientific Laboratory. A new improved detonator cable connector (Fig. 2.13) was used, and a new mounting pad recessed into the HE replaced the pad and chimney tube arrangement (Fig. 2.14). A J-slot or bayonet spring-type lock was used on both the detonator and the cable connector.

Since the sheet-metal sphere cases were the first ones to be manufactured, provisions had to be made for securing and routing the detonator cables. Practically all the preliminary work on cable routing was done by D. R. Cotter in conjunction with C. J. Kunz during the testing and proving [redacted] (See "Firing and Fuzing Reports" by D. R. Cotter.) This was necessary because cable lengths and routing from X-unit to detonators are inseparable, and the lengths had to be determined to complete the X-units. Very little revision of the routing was necessary from the original mock-up to the final version. The only additional improvement was to provide cable clips with Trimount Dot fasteners soldered to them which could be pushed into holes drilled at selected points in the sphere cases and countersunk from the inside. These clips slip over plastic insulators which are available in groupings from 2 to 6. This arrangement proved to be very satisfactory, as can be seen from Figs. 2.15 and 2.16, especially when it is realized tha[redacted]

Another difference from previous weapons was the use of [redacted]



The exterior covering of the weapon was a fabricated aluminum sheet-metal three-segment cylindrical can which served as a security cover and as protection from weather. All joints and crevices were sealed with lead tape, thereby making the assembled unit waterproof. The design of the protective cans and other handling equipment is discussed in Sec. 2.3.

2.2.2 Booster

Everything that has been written about [redacted] may be applied to the Booster. Only one

[redacted]

slight modification was made. [redacted]

as explained in the report by R. D. Krohn, 3.1.4 Nuclear Division. [redacted]

2.2.3 [redacted]

Th[redacted]was the first attempt by the Los Alamos Scientific Laboratory to investigate the phenomena of a thermonuclear reaction. As such [redacted]was designed to facilitate the acquisition of experimental data to confirm theoretical calculations. No attempt was made to test an actual weapon, but, instead, the design concept was based upon a configuration that would provide the reaction in such a manner that the maximum number of measurements could be recorded.

The final test device was the culmination of nearly two years of intensive research and development at Los Alamos. Following the directives of the Family Committee and the Theoretical Division; GMX Division, W Division, and CMR Division collaborated to produce the gadget that became [redacted]Since so many groups and individuals contributed to the over-all program, this report can only refer those interested in specific details, of either the gadget or its development, to the many reports written by the participating divisions at Los Alamos.

2.2.4 [redacted]

Because the bomb was to be fired from a stationary position on a 300-ft tower, it was possible to reduce the weight and number of components to a minimum. This unit was stripped of the nonessentials. The bomb consisted of the following components [redacted](powered by an external source), standard load ring, wiring, and 1E20 detonators [redacted]HE sphere containing [redacted]A lightweight protective cover can encased the unit and also met the requirements as a security cover.

The unit was assembled and prepared for shipment at Sandia Corporation, Area No. 2, under the supervision of TU 3.1.4.2 and received the same rigid inspection as any stockpile bomb.

The HE sphere consisted of [redacted]points of detonation, each point having a double bridge-wire detonator. Since all HE was grade one it was prepared and inspected to meet stockpile specifications [redacted]was substituted without any problem. After the sphere was assembled and the segments replaced, the wire harness and mounting flange were installed. All cable connector ends and detonator holes were sealed in the usual manner.

To compensate for the absence of the heavy ballistic case, support beams had to be installed. The beams served as a support for the unit in the shipping crate, on the laboratory stand, and on the firing stand in the tower (see Fig. 2.18).

The cover can made up of three sections housed the unit. The forward portion was bolted securely to the polar cap of the sphere. An opening was provided for the removal of the trap-door charges and also made it accessible to the detonators. This opening was sealed off by a cover plate when not in use. The center section was made up of four cowling panels and, when bolted together, formed the major diameter. Cutouts for the trunnions were made in the side panels as all lifting was done at these two points (the lug was not used). A drumlike cover made up the rear portion. This in turn bolted to the rear polar cap flange, protecting the X-unit. A more detailed description of the cover can may be found elsewhere in the report.

2.3 HANDLING EQUIPMENT

The basic configuration was different on three of the four units which were tested on Operation Greenhouse; this diversity complicated the handling problems. An attempt was made by the Engineering Planning Division to minimize the amount of equipment required for handling these

[redacted]

units, and with this in view the equipment was made as versatile as possible. To accomplish this end, certain pieces of equipment were designed for use with all three units. In general, the handling equipment was divided into three categories: (1) shipping and storage containers, including nuclear salvaging equipment, (2) ship-to-tower-cab handling, and (3) tower equipment.

Because of the diversity in size and geometry of the units, it was necessary to design and fabricate individual crates for each type.

The ship-to-tower-cab equipment was, with minor differences for each type of unit, generally the same.

• The tower equipment consisted mainly of firing stands. [redacted]

The basic components of each unit were examined carefully to determine what modifications would be required to make each unit adaptable to the same handling equipment required by the other two. The modification to the basic units will be covered in detail later in this report.

2.3.1 General

The planning and the design of all handling equipment were the responsibility of the Engineering Planning Division, 3.1.4.1. The following items used were identical for each unit: Yale and Towne electric lift truck, 6-ton Diamond T truck, strongback, nuclear salvaging equipment, and unit crates.

(a) Yale and Towne Electric Lift Truck. This truck was of a 6-ton capacity and was used for general unit handling aboard the USS Curtiss (AV-4).

(b) Six-ton Diamond T Truck. This truck was modified after arrival at Eniwetok for transporting units from the ship to the tower. The truck was modified by replacing the dump body with a steel flat bed. Pad eyes were strategically located on the bed for securing the various units to the truck.

(c) Strongback. The following requirements determined the design of this piece of equipment: a safety device to work on the tower guide rails, adaptability to all units, and capability of rotation with full load.

To meet the first requirement, a rail gripper was located on both ends of the strongback. The grippers were designed to grab the guide rails in case of a hoist or cable failure. The grippers were tested at Sandia and proved to be 100 per cent reliable. They also acted as guides to prevent the wind from deflecting the unit during the ascent to the tower cab.

Suspension arms and fittings for the individual units were incorporated to meet the second requirement.

A kingpin capable of 360° rotation met the third requirement.

(d) Nuclear Salvaging Equipment. This equipment was furnished for salvaging the nuclear components during transit to and from the Forward Area in the event of a disaster.

Standard 30- and 55-gal drums modified to receive lanyards and dye packages were used.

The 30-gal drums were chosen for use with air shipments and 55-gal drums for use with surface shipments.

The 30-gal drums gave a capacity of 250 lb at half buoyancy, and the 55-gal drums gave a capacity of 425 lb at half buoyancy.

To make certain that the drums would be clearly visible from the air, each drum was equipped with a dye marker (Spec. M-566B) and painted with an iridescent red paint. In addition, each drum was equipped with a corner radar reflector.

Two lanyards were provided on each drum for attaching the nuclear carrying cases. Lanyards were also provided for lashing the drums together after placing them in the water.

(e) Shipping Crates. Although the crates varied in size, the basic construction was the same. A structural-steel base frame with plywood flooring and reinforced plywood sides was used throughout.

Saddles were incorporated in the base frame to receive the yokes attached to the units. The yokes were clamped in the saddles, thus securing the bomb in the crate for shipment.

Lifting lugs for use with the crate-handling slings and truck tie-downs were mounted on the base frame. These slings were used for loading the crates aboard ship, and the truck tie-downs were used for ship-to-tower delivery.

2.3.2 [redacted]

A specially fabricated aluminum-alloy can was placed around [redacted] The can was made in three sections

[redacted]

consisting of the front section, the split-band section, and the rear section. The front and rear sections bolted on the front and rear polar cap flanges, respectively. The split-band section, made of four 90° segments, rested on the flanges of the front and rear sections. With the four segments bolted together, a completely enclosed can was formed.

The rear section was made in two pieces so that the rear piece could be removed for X-unit assembly, while the forward piece remained bolted to the rear polar cap.

After the forward and rear sections were mounted, two yokes were bolted into position at the bottom of both the forward and rear sections. The yoke mounting bolts passed through the can and the respective polar cap flanges, thus securing the yokes and making them an integral part of the bomb. The crate, laboratory assembly stand, and the firing stand were all designed to accommodate the yokes.

Trolley mounting brackets were designed to be bolted to the forward and rear yokes on both sides of the bomb. The brackets were bolted in position at the bottom of the tower. The roller skates mounted on these brackets were used to stabilize the bomb during ascent.

Trunnions were fabricated and bolted to the sphere, using the existing trunnion pads cast into the sphere. These trunnions took all handling loads while the bomb was being transferred from ship to tower cab. Terminal fittings for the strongback sway braces were located on the top of the front and rear can sections.

(a) Laboratory Equipment. A laboratory assembly stand and an X-unit dolly were required. The stand, which positioned the bomb at a 40-in. center line, was constructed of two parts, with each part consisting of two legs and the necessary stabilizing members running between them. A square socket which slipped over the yoke was welded to the top of each leg. The leg assemblies were slipped over the yokes, leaving the space under the bomb clear for the X-unit dolly.

The X-unit dolly was a modified [redacted] unit dolly. The modification entailed reworking the mounting lugs to fit the [redacted].

(b) Tower-cab Equipment. The only tower-cab equipment necessary for this bomb was nuclear insertion tools and firing stand. Since the zero point in the tower cab was approximately $17\frac{3}{4}$ in. from the center line of the hoist, it was necessary to design a stand which could accomplish this movement. The firing stand was fabricated in two sections consisting of a track assembly and the stand proper. The stand incorporated rollers which rode on the track, and locking screws were provided for locking the stand to the track after the unit was positioned.

The H-2 insertion gea[redacted] was previously designed and fabricated on an experimental basis and proved very satisfactory for this operation. The tools consisted of two slides which bolted to the sphere and the front of the protective can. A carriage, carrying the vacuum cup, rode on the slides. The carriage was placed in position with the vacuum cup against the face of the trap door, and vacuum was applied. The charge was withdrawn, the carriage removed from the slides, and the charge placed on a rubber mat on the floor. After both the outer and inner charges had been removed, the nuclear assembly team took over. With the nuclear assembly complete, the charges were replaced, and the bomb was buttoned up. All insertion equipment was returned to the ground for evacuation.

(c) Ship-to-tower-cab Handling. While still resting on the assembly stand, the completed bomb was fitted with strongback, arms, and sway braces. The assembly stand was removed, and the bomb was placed on the crate base and secured. The assembled bomb and crate base were then placed on the electric lift truck. All handling from this point was accomplished by the strongback.

The electric lift truck with the bomb aboard was run into position on the main deck aft. The unit was then hoisted by the ship's No. 2 crane. The bomb and all auxiliary equipment were lowered to the modified truck in the LSU tied alongside the ship. With the bomb in position on the truck, the crate was secured to the truck bed.

The LSU left the ship and proceeded to the beach. Upon beaching, the truck with equipment and personnel aboard proceeded to the tower area.

At the tower, with the truck backed into position, the clamps securing the bomb to the crate base were released, and the hoist block was attached to the strongback. The bomb was hoisted clear of the crate base into position so that the strongback rail grippers were located approximately 1 in.

below the end of the guide rails. The grippers were aligned with the guide rails, and the unit was hoisted approximately 3 ft. At this time the roller skate mounting brackets were bolted into position, and the roller skates were attached. The bomb was hoisted again and the roller skates were engaged on the guide rails. The bomb ascent was stopped after engagement of the roller skates, and certain personnel ascended to the tower cab via the skip hoist. With these people stationed in the tower cab the bomb ascent was begun. The bomb ascent was observed and controlled from the ground to approximately the midway point, and then the personnel in the tower cab observed and controlled hoisting operations.

When the bomb had been hoisted through the cab trap door to a position approximately 3 ft above the tower floor, the trap-door beams and panels were replaced. The roller skates and mounting brackets were removed and the firing stand was then located under the bomb, at which time the unit was lowered into position. The hoist block was disconnected, hoisted through the roof opening, and secured to the tower structure above the cab. With the strongback, arms, and sway braces removed, the bomb was rolled into position over the zero point. All handling equipment, with the exception of the insertion equipment, was placed in the skip hoist and returned to the ground to be evacuated.

2.3.3 [redacted]

[redacted] using the sheet-metal aluminum sphere case, was used with a can similar to [redacted] enclosing it. Since the light-weight sphere case used did not have the necessary trunnion pad mounts, a longitudinal beam was located between the front and rear polar cap flanges on either side. These beams divided the hoisting loads between the two sphere flanges. In all other respects the can assembly was the same [redacted]

(a) Laboratory Equipment. The same type of equipment, with minor modifications, was used [redacted]

(b) Tower-cab Equipment. The two items required were a firing stand and a nuclear loading trough.

[redacted], a trough was the only equipment required for loading. The trough was bolted to the boss provided on the sphere and cantilevered from this point.

(c) Ship-to-tower-cab Handling. [redacted] was handled in the same manner [redacted] with minor exceptions.

2.3.4 [redacted]

[redacted] as received from Los Alamos, consisted of an HE assembly with [redacted]

The X-unit was mounted on a welded angle framework attached to th[redacted] the X-unit was arbitrarily placed at the bottom.

To afford environmental protection, [redacted] which attached to a metal box covering the X-unit.

[redacted]

(a) Laboratory Equipment. An assembly stand, unit handling sling, and an X-unit dolly were required for laboratory and assembly use. The laboratory stand was constructed of steel tubing and was designed to receive [redacted] The stand was triangular in configuration and could be disassembled for logistic purposes.

The handling sling was fabricated of $\frac{5}{8}$-in. cable, incorporating a hook fitting at the top and a tubular spreader bar. Terminal fittings were designed to fit the trunnion beams, and these were attached to the ends of the cables. [redacted] dolly was used with this bomb.

(b) Tower-cab Equipment. This equipment consisted of a firing stand and four tie-down rods.

Very stringent requirements were placed on the firing stand [redacted] Owing to the complex instrumentation system, [redacted] This flexibility was necessary because of the close location tolerances over [redacted] The stand designed to meet these requirements was made in two parts. The main V-shaped structure was mounted on roller assemblies and rode in tracks mounted on the substructure. A jack was located at the top on either side of the V-structure, and the trunnion beams [redacted] rested on these jacks. The longitudinal and traverse movement of the main structure on the substructure was accomplished by the use of lead screws.

A turnbuckle was connected between the stand and [redacted]

The tie-rods were used to secure [redacted] to the tower floor after positioning. This secured [redacted] to the tower and prevented movement of the unit relative to [redacted]

(c) Ship-to-tower-cab Handling. The [redacted] was removed from the laboratory assembly stand and placed on the [redacted] cradle. The transport cradle was designed for transporting [redacted] and was constructed of structural steel. Handling [redacted] between the laboratory stand and the transport cradle was accomplished by the use of the [redacted] handling sling. After being placed on the transport cradle, the tie-downs between [redacted] and the cradle were installed. The strongback, arms, and sway braces were installed [redacted] and the complete assembly was placed on the electric lift truck. [redacted] from this point to the base of the tower was handled in the same manner [redacted]

With the truck backed into position, the tie-downs securing the complete assembly to the truck were disconnected, and the hoist block was attached to the strongback [redacted] with cradle attached, was hoisted free of the truck, and the rail gripper was guided onto the rails. At this point [redacted] ascent was stopped and the roller skates were attached to the arms on the cradle. With this operation completed, the bomb was hoisted and the roller skates were engaged in the guide rails. At this point [redacted] ascent was halted and certain personnel ascended to the tower cab in the skip hoist.

[redacted] ascent was handled in the same manner as [redacted]

After the unit had been hoisted into the tower cab, the removable I beams and floor panels were replaced, and the assembly was positioned on the floor. Four tie-downs securing [redacted] to the cradle were disconnected; the main hoist was disconnected and taken through the roof of the cab. The traveling crane was brought into position [redacted] and connected to the strongback.

At this time [redacted] was hoisted and traversed into position over the firing stand base which had been previously indexed [redacted] The main structure of the firing stand was positioned, within adjustable limitations, as far away from [redacted] as possible. After lowering [redacted] on the stand, enough slack was given on the hoist cable to allow [redacted] to pivot on the trunnions until the turnbuckle could be connected between the [redacted] and the stand. The turnbuckle was then secured, and the strongback, sway braces, and arms were removed [redacted]

in this position, the nuclear insertion was accomplished by the nuclear team. A proper working height was achieved by the use of a wooden platform.

[redacted] Four adjustable tie-downs which connected the fittings on the trunnion beams and the pad eyes on the floor were installed at this time.

Positioning was accomplished by adjusting the tie-downs, lowering the jacks, and simultaneously assuring that [redacted] This measurement was checked with feeler gauges and dial indicators.

All equipment was then taken to the bottom of the tower for evacuation.

2.3.5 [redacted]

The Booster assembly and handling were [redacted] However, a special firing stand to position the bomb at a 75-in. center above the tower floor was used. The firing stand was made vertically adjustable by the use of jack pads on the four floor contact points. The Booster was handled by the bridge crane in the tower cab, which precluded the use of tracks.

2.3.6 Weapon Auxiliary Equipment Design Data

All handling equipment and unit design drawings pertaining to weapon assembly for Greenhouse are available from the Sandia Corporation Drawing File Section.

2.4 TRAINING PROGRAM AT LOS ALAMOS AND SANDIA BASE

To familiarize the personnel of TU 3.1.4.2 and other agencies concerned with the tower operation, a brief but thorough training course was conducted at Los Alamos Scientific Laboratory Area TA-33 (tower site).

The units selected for Operation Greenhouse differed greatly in size, weight, and shape from those used on previous tests. Therefore experience in the use of special handling equipment was necessary. This could best be accomplished by numerous dry runs prior to departure to the Forward Area. The value of this training was demonstrated by the efficient performance of the team during Operation Greenhouse.

Groups participating in the training program were the associated TU 3.1.4 and CMR Division of Los Alamos and the Weapons Assembly Group of Sandia Corporation. The success or failure of these aspects of the test rested in the hands of these groups; therefore teamwork and perfection were of utmost importance.

Three inert training units were used for the practice runs. [redacted] To simulate actual weight, concrete was substituted for HE; therefore everything except wiring and detonators was comparable to the live units.

During the practice runs [redacted] it was found that there were no great problems involved in transporting or positioning the units in the tower cab; however, the Nuclear Division did find it necessary to make minor modifications on the insertion tools.

Due to its tremendous weight and siz[redacted] did create problems of transportation and handling. Positioning the unit in the tower was no easy task, but with the able assistance of the Engineering Department these problems were quickly solved. By the end of the training period, the dry runs became routine and uneventful.

All handling equipment procedures, detail check sheets, and associated papers were formulated during the period of the tower trial work at Los Alamos.

The tower erected for the training program was adequate and, although only 25 ft high (ground to cab floor), it served its purpose well. A skip hoist was not installed in this tower since its only function was to convey personnel. It was decided that a steel ladder would suffice for this purpose. The tower cab was constructed according to specifications from the approved drawings of Holmes and Narver 200-ft tower design.

2.5 SUPPLY AND LOGISTICS

Prior to departure from Sandia, Organization 3.1.4.2, with the able assistance of TU 3.1.4.7, procured all weapons, tools, handling equipment, and expendables required for weapon assembly and delivery. Sandia Corporation, Organization 2232, packaged all supplies and equipment, except weapons, which were assembled, sealed, and crated in Area No. 2 by Organization 2233 under the supervision of Organization 3.1.4.2. There was no evidence of inadequate packaging.

The problem of obtaining adequate spare weapons, components, and handling equipment to carry out successfully an operation at a remote location was of major concern. In most cases 100 per cent spares were provided. However, very few were used or even unpacked but were readily available in an emergency.

A survey of the machine shop facilities aboard the USS Curtiss was made during the planning phase of Operation Greenhouse. Only tools and equipment not readily available aboard ship were taken along. A supply of metal stock was procured to permit modification or fabrication of items of equipment if the need arose as the operation progressed.

A shipping manifest, with a complete listing of tools, equipment, and supplies, is furnished as Appendix B.

Chapter 3

Operations at Forward Area

3.1 GENERAL

The movement of materials and personnel to the Forward Area is covered in Greenhouse Report, Annex 9.2, Parts VII and VIII.

Ship's facilities and their use are discussed in Sandstone Report, Annex 15, Vol. 36, Part I, "LAJ-9A Activities." Modifications to ship's facilities for Operation Greenhouse are discussed in Greenhouse Report, Annex 9.2, Part I, with recommendations for future modifications.

The four Greenhouse experimental weapons were assembled under rigidly controlled conditions; safety and reliability were considered of paramount importance. Check sheets were used to ensure at least two persons inspecting each step in the assembly, delivery, and final positioning of each weapon.

Since the methods employed in handling the individual weapons from their storage location in Shop 18 to Shop 1 and the delivery from Shop 1 to a tower are for all practical purposes identical, it is unnecessary to give a detailed description of the procedures for each of the Greenhouse bombs. A comprehensive step-by-step procedure, including photographs, [redacted] is given in Sec. 3.3, and because of the complexity of the operations for [redacted] similar data are included in Appendix A. Highlights of the other weapon peculiarities are included as captioned photographs.

3.2 RADIOCHEMISTRY SAMPLES

Organization 3.1.1 required the placement of certain radiochemistry samples in the tower cab after final positioning [redacted] bombs. In order to limit the number of persons participating in the final phase of bomb preparation, Organization 3.1.4.2 positioned the Rad-Chem samples in the tower cab. Melvin G. Bowman supplied the samples and placement instructions, which were attached to each sample as follows:

[redacted]

3.3 [redacted] STANDARD OPERATING PROCEDURE

3.3.1 Major Mechanical Assembly [redacted]

1. Transfer unit from its storage space in Shop 18 to Shop 1, along with spare HE charges (Figs. 3.6 to 3.7)
2. Remove crate sling and uncrate unit
3. Install strongback and lift unit from crate base (Fig. 3.8)
4. Modify support beams to receive lower roller assembly (do not install roller assembly)

5. Mount laboratory stand on unit and lower into position; install grounding strip (Fig. 3.9)
6. Remove strongback
7. Remove cover plates from forward end of unit (Fig. 3.10)
8. Loosen trap-door bolts and remove lightweight trap door and remove chimney tube
9. Install H-2 equipment
10. Place vacuum cup in position and disengage trap-door retainer ring
11. Remove trap-door charges for inspection (Fig. 3.11)
12. Check trap-door charges for defects (Fig. 3.12)
13. Remove H-2 equipment
14. Inspect pit; clean trap-door shims
15. Make trial nuclear insertion
16. Install H-2 equipment
17. Replace trap-door charges
18. Engage trap-door retainer ring and install chimney tube
19. Mount lightweight trap door and secure bolts
20. Remove rear section of cover can (X-unit) (Fig. 3.13)
21. Remove center sections of cover can (four sections)
22. DCO detonators (Fig. 3.14)
23. DCO detonator cables; check all connections (Fig. 3.15)
24. Remove detonators' hole plugs and check HE at Booster position
25. Install detonators (Fig. 3.16)
26. Mount X-unit (Fig. 3.17)
27. Assembly test (Cotter check sheets)
28. Replace cover can and replace silica gel (Fig. 3.18)
29. Seal unit
30. Install strongback and sway bracing (Fig. 3.19)
31. Hoist unit and remove laboratory stand
32. Place unit on crate base and secure tie-downs
33. Hoist unit on Yale lift with spare HE charges (Fig. 3.20)
34. Unit ready for delivery to main deck aft

3.3.2 Delivery from Shop 1 to Top of Tower and Final Assembly [redacted]

Operation	Estimated Cumulative Time (min)
1. LSU, with truck aboard, alongside AV-4 (Fig. 3.21)	−15
2. Clear main deck aft and prepare to open doors of Shop 1	−10
3. Run lift truck with unit and equipment to main deck aft (Fig. 3.22)	0
4. Lower pendant and attach to unit; secure hand lines to unit	1
5. Hoist unit clear of lift truck and lower onto truck in LSU (Figs. 3.23 to 3.25)	6
6. Secure unit to truck tie-downs and disconnect pendant (Fig. 3.26)	8
7. Transfer all auxiliary equipment from AV-4 to LSU	11
8. Advance tower crew boards LCPL; then proceed to tower cab and remove floor panels (attach safety belts and ropes)	13
9. All remaining tower personnel board LSU	13
10. LSU leaves AV-4 for island (Fig. 3.27)	15
11. LSU beaches and lowers ramp (Fig. 3.28)	30
12. Truck carrying unit and all auxiliary equipment leave LSU (Fig. 3.29)	32
13. Personnel board the truck carrying the unit and proceed to tower	33
14. Truck arrives at base of tower	38
15. Advance tower crew returns to base of tower	38

Operation	Estimated Cumulative Time (min)
16. Personnel dismount and truck carrying unit is backed into position under tower (Fig. 3.30)	41
17. Clamps securing unit to crate base are removed and main hoist block is attached to unit; secure hand lines to unit	51
18. Hoist unit clear of crate base and engage rail grippers in guide rails (Fig. 3.31)	58
19. Attach lower roller assemblies; check stabilizing rods for tightness	64
20. Hoist unit and engage lower rollers in guide rails; release safety rollers (Fig. 3.32)	70
21. Place all auxiliary equipment on skip hoist and remove truck from base of tower	73
22. Six men proceed to tower cab	80
23. Lower skip hoist below cab floor	88
24. Main hoist ascent started; one man on ground watches progress of unit as long as possible; continuous telephone contact is maintained between tower cab and hoist operator (Fig. 3.33)	89
25. Man on ground transfers control to men in tower when unit cannot be clearly seen and hoist controls are taken over by men in tower cab; unit is guided through trap door; ascent is completed (Fig. 3.34)	97
26. Removable beams are replaced and floor panels are reinstalled (Fig. 3.35)	100
27. Remove lower roller assemblies from unit	103
28. Place firing stand in position under unit	105
29. Lower unit onto firing stand (Fig. 3.36); lock two zero side stand bolts and disconnect hoist block	107
30. Two men remove strongback from unit while two other men proceed to tower roof with cable and cable clamps; hold limit switch closed while hoist block is brought into position above roof; proceed to tie-off hoist block; place canvas cover over roof hole; word is passed to tower base to begin salvage of main hoist	117
31. Move firing stand along tracks to proper position over zero point (Fig. 3.37)	
32. Raise skip hoist to tower cab and place strongback and associated equipment in it	120
33. Send skip hoist to tower base with equipment and simultaneously check position of unit over survey zero	124
34. Return skip hoist to tower cab with Henderson and nuclear team; lower skip hoist to base of tower	136
35. Shuster and one man ascend with TMTT equipment	142
36. Prepare unit for nuclear team and warm up TMTT equipment	147
37. Insert nuclear material and check TMTT	177
38. When nuclear team has finished, complete assembly, connect detonator, and seal front of unit	182
39. Place the three radiochemistry samples at locations indicated on container	
40. All personnel return to base of tower	200

3.4 [redacted] STANDARD OPERATING PROCEDURES

[redacted] procedures are identical up to tower-cab positioning on the firing stand and nuclear insertion. Photographs in Figs. 3.38 to 3.50 are in chronological order and may be integrated into [redacted] step-by-step procedure; refer to Sec. 3.3 for comparison.

The 1E22 detonator installation procedures are the same for [redacted] Figures 3.38 to 3.43 apply.

3.5 [redacted] STANDARD OPERATING PROCEDURE

Figures 3.51 to 3.60 are in chronological order with explanatory captions illustrating [redacted]

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Appendix A

Bomb Assembly and Delivery Schedules and Check Sheets [redacted] (Weapons Technical Inspection Data Book)

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BOMB SUPERVISOR'S CHECK SHEET

Bomb No. _____ Time/Date _____
X-unit No. _____ Type _____

A. ASSEMBLY

1. [ ] Bomb is inspected for physical damage, and grounding strap is attached
2. [ ] Inspect pit, attachment of nuclear trough, and insertion of front ring
3. [ ] Inspect alignment of the hohlraum onto saddle and front ring
4. [ ] X-unit No. ____ inspected and approved
   (a) Electrical check sheets indicate cable, DCO, and high-potential test
   (b) All connectors and cables secure
5. [ ] X-unit installation approved
6. [ ] Detonator cable routing and attachment approved
7. [ ] Detonators installed, individually inspected, and approved
8. [ ] Case sealing inspected and approved
9. [ ] (a) Bomb properly set on transport cradle
   (b) Tie-downs inspected
10. [ ] Bomb prepared for movement at ____ hours

B. CHECK SHEETS RECEIVED AND APPROVED

1. [ ] Detonators
2. [ ] Detonator cable
3. [ ] [redacted] check sheet
4. [ ] Electrical
5. [redacted] component and auxiliary equipment released with weapon
6. [ ] Nuclear

Check Completed by _____

Date _____ Time _____

[redacted] CHECK SHEET

Bomb No._____ Time/Date Commenced_____

A. POSITION BOMB ON TRANSPORT CRADLE

1. [ ]
2. [ ]
3. [ ]
4. [ ]

B. POSITION BOMB ON LAB STAND [redacted]

1. [ ] Remove unit handling beams
2. [ ] Remove case covers
3. [ ] Inspect detonator Booster holes and clean
4. [ ] Install X-unit mount
5. [ ] Install X-unit
6. [ ] Route detonator cables and attach to X-unit
7. [ ] Install and connect detonators
8. [ ] Replace case covers and install X-unit cover
9. [ ] Seal unit with lead foil tape
10. [ ] Attach positioning beams with pins up (away from X-unit)
11. [ ] Attach hoisting beams
12. [ ] Place bomb on transport cradle (hoisting arms line up with roller skate fitting)
13. [ ] Remove positioning beams and reattach with pins down (toward X-unit)
14. [ ] Attach tie-downs to secure bomb to transport cradle
15. [ ] Attach strongback to hoisting beams and attach stabilizing rods
16. [ ] Hoist unit to Yale lift truck and tie down, using turnbuckles

C. REMARKS

Check Completed by_____

Date_____ Time_____

1E22 DETONATOR CHECK SHEET

Bomb No. _____ Detonator Lot No. _____ Box No. _____
DCO Ser. & Mod. No. _____

A. DETONATOR INSPECTION

1. [ ] All detonators bear the same lot number
2. [ ] Resistance is below 0.1 ohm
3. [ ] Insulator is not chipped or cracked
4. [ ] Retaining ring is in place
5. [ ] Pellet face is free of defects
6. [ ] Pellet protrudes from barrel
7. [ ] Barrel body assembly is tight

Rejections (Give serial number and cause)

Remarks

B. ASSEMBLY CHECKS

1. [ ] HE charge and pellet surfaces have no defects
2. [ ] Pellet is pressed against the HE charge
3. [ ] Detonator coupling nut is locked in place
4. [ ] Side arm is lined up with the cable
5. [ ] Male connector coupling nut is locked in place

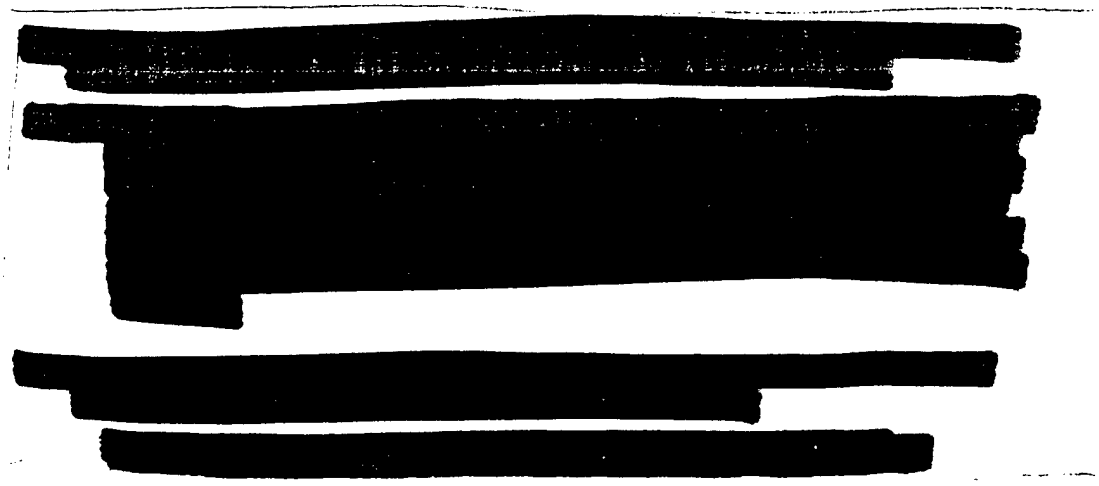
Remarks

Inspection by _____ Time/Date _____

Assembly by _____ Time/Date _____

DETONATOR CABLE CHECK SHEET

Bomb No._____ Time/Date Commenced _____



C. REMARKS

Check Completed by _____

Date _____ Time _____

[redacted]

[redacted] COMPONENT AND AUXILIARY EQUIPMENT TO ACCOMPANY WEAPON FROM SHOP 1

1. [ ] Toolbox, large
2. [ ] Toolbox, small (for firing party)
   a. [ ] 2 Speed wrenches with $\frac{5}{8}$-in. sockets
   b. [ ] 2 $\frac{9}{16}$-in. box end wrenches
   c. [ ] 1 Crescent wrench, 10 in.
   d. [ ] 1 Crescent wrench, 15 in.
   e. [ ] 1 Grease pencil
   f. [ ] 1 6-ft tape
   g. [ ] 1 Protractor w/level
   h. [ ] 1 $\frac{9}{16}$-in. socket
   i. [ ] 1 Tape, roll
3. [ ] Gray box
   a. [ ] 2 Safety belts and ropes
   b. [ ] Lead tape
   c. [ ] Helmets
   d. [ ] Tag lines
   e. [ ] Grounding cable
4. [ ] Roller skates w/$\frac{1}{2}$-in. bolts in place
5. [redacted]
   a. [ ] Key to box
   b. [ ] Drill plate
   c. [redacted]
   d. [ ] Brass handling bracket
   e. [redacted]
   f. [ ] Rope
   g. [ ] 3 $\frac{3}{8}$-in. studs
   h. [ ] 4 $\frac{1}{2}$-in. bolts
   i. [ ] 4 $\frac{1}{2}$-in. lock washers
   j. [ ] 2 Locating pins
   k. [ ] Locating brackets
   l. [ ] Bracket dowels
   m. [ ] 8 Screws, 8-32
   n. [ ] 3 $\frac{3}{8}$-in. nuts for studs
6. [ ] Items on truck
   a. [ ] Bomb
   b. [redacted]
   c. [ ] Firing party toolbox
   d. [ ] Toolbox, brown
   e. [ ] Gray box
   f. [ ] 2 Skates
   g. [ ] 2 Saddles

Checked by _____

Date _____ Time _____

[redacted]

STANDARD OPERATING PROCEDURE FOR MAJOR MECHANICAL ASSEMBLY [redacted]

1. Transport bomb from Shop 18 to Shop 1
2. Remove crate sling and uncrate bomb
3. Attach positioning sling and lift bomb onto transport stand
4. [redacted]
5. Inspect pit; fit nuclear trough and insert front ring into pit
6. [redacted]
7. [redacted]
8. Place unit on lab stand with front (plane) end plate up
9. Remove unit handling beams
10. Remove case cover
11. Inspect Booster holes
12. Install X-unit mount
13. Install X-unit
14. Route detonator cables and attach to X-unit
15. Install detonators and connect to detonator cables
16. Replace case cover and install X-unit cover
17. Attach positioning beams with pins up (away from X-unit)
18. Attach hoisting beams
19. Place bomb on transport cradle
20. Remove positioning beams and reattach with pins down (toward X-unit)
21. Attach tie-downs to secure bomb to transport cradle
22. Attach strongback to hoisting beams and attach stabilizing rods
23. Hoist unit on Yale lift and tie down with turnbuckles
24. Unit ready for delivery to main deck aft

STANDARD OPERATING PROCEDURE FOR DELIVERY [redacted] TO TOP OF TOWER AND FOR FINAL ASSEMBLY

1. LSU, with truck aboard, alongside AV-4
2. Clear main deck aft and prepare to open doors of Shop 1
3. Run lift truck with unit and equipment to main deck aft
4. Lower pendant and attach to unit; secure hand lines to unit
5. Tower unit to LSU and position on truck
6. Secure unit to truck tie-downs
7. Transfer all auxiliary equipment to LSU
8. LSU leaves AV-4 for island
9. LSU beaches and lowers ramp
10. Truck, with unit, drives off LSU and proceeds to tower with personnel
11. Truck arrives at base of tower
12. Personnel dismount and truck backs into position under main hoist (equipment is removed from truck)
13. Clamps securing unit to truck are removed; clevis adaptor is removed and main hoist is attached to unit; hand lines are secured to unit
14. Unit is raised above truck; truck is removed
15. Unit is lowered and turned 90°
16. Unit is raised and upper rail grippers are engaged in guide rails
17. Attach lower rollers and engage on rails; release safety rollers
18. Personnel proceed to tower in skip hoist with tools and equipment
19. Main hoist ascent is started
20. Tower cab takes control of main hoist
21. Unit is guided through trap door; ascent is completed
22. Safety rails are removed, and floor beams and panels are replaced (skip hoist is lowered for RWH)
23. Remove lower rollers from unit here
24. Lower unit to floor; remove security cover; remove main hoist pulley block from unit
25. Pulley is removed to top of tower, and clevis adaptor is attached
26. Clamps securing unit to unit base are removed
27. [redacted]
28. [redacted]
29. Bridge crane hoist is attached to unit; unit is raised from base and set on jacks of firing stand; note: check that jack collars are seated on base
30. Loosen stabilizing rods on strongback; remove strongback; tilt unit
31. Build platform on horses back of unit
32. Nuclear team takes over and makes insertion
33. [redacted]
34. Place tie-down rods (unit to floor) and adjust (further adjustment also necessary on frame)

[redacted]ASSEMBLY OPERATIONS ON TOWER

1. [redacted]
2. Attach locating brackets
3. Check locating brackets with drill plate
4. Attach brass handling brackets and cable
5. Prepare $\frac{1}{2}$-in. bolts and 8-32 screws
6. Attach saddle brackets to bomb
7. [redacted]
8. Attach four $\frac{1}{2}$-in. bolts and lock washers; do not tighten until step 11
9. [redacted]
10. Tighten eight 8-32 screws
11. Tighten four $\frac{1}{2}$-in. bolts
12. Remove window cover plate and clean bottom plate
13. Attach dial indicator for vertical displacement
14. Check evenness of front ring seating with scale
15. [redacted] make general inspection

[redacted]POSITIONING OPERATION

1. Advance unit evenly toward X-ray tube
2. Stop when 1 in. from tube cover
3. Adjust height (0.070 in.) and tilt (15°)
4. Advance unit until $\frac{1}{16}$-in. past positioning holes toward index
5. Readjust height (0.050 in.) and tilt (parallel to tube cover)
6. Lateral adjustment to center unit
7. Attach turnbuckles and make hand tight, doing rear ones first
8. Adjust turnbuckles until locating pins slide into holes easily; secure locknuts
9. Check height and evenness and readjust jacks if necessary; should be parallel with X-ray tube cover and have 0.031-in. clearance
10. Do not leave locating pins in holes

[redacted]

11. Attach forward and lateral dial indicators
12. Record readings of indicators and feeler gauge clearances at four points

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Appendix B

Shipping Manifest

Page 30 is blank.

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
258	1	Toolbox, Kennedy kit 520	1
258	2	Wrenches, open end, box end, $\frac{3}{8}$ to $\frac{3}{4}$ in.	1 set
258	3	Tape, 6 ft	2
258	4	Thickness gauge	1
258	5	Scriber	1
258	6	Combination set, 12 in.	2
258	7	Tap, $\frac{3}{8} \times 16$ in.	1
258	8	Tap, $\frac{1}{2} \times 20$ in.	1
258	9	Tap, $\frac{9}{16} \times 20$ in.	1
258	10	Tap handle, T	1
258	11	Tap handle, chuck type	1
258	12	Knife, electricians	1
258	13	"C" clamps, 1 in.	1
258	14	Screwdriver, $\frac{1}{8} \times 2$ in.	2
256	15	Drills, HS steel, $\frac{1}{64}$ - $\frac{1}{2}$ in. w/index	1 set
258	16	Drills, HS steel, A to Z w/index	1 set
257	1	Socket set, $\frac{1}{2}$-in. dr., $\frac{7}{16}$ to $1\frac{1}{4}$ in.	1
257	2	Socket set, $\frac{3}{8}$-in. dr., $\frac{5}{16}$ to $\frac{3}{4}$ in.	1
257	3	Socket set, $\frac{1}{4}$-in. dr., $\frac{5}{16}$ to $\frac{3}{4}$ in.	1
257	4	Socket set, $\frac{3}{4}$-in. dr., $1\frac{1}{2}$ to 2 in.	1
257	5	Speed wrench handle $\frac{1}{2}$-in. dr.	1
257	6	Speed wrench handle $\frac{3}{8}$-in. dr.	1
257	7	Ratchet wrench, $\frac{1}{2}$-in. dr.	3
257	8	Ratchet wrench, $\frac{3}{8}$-in. dr.	3
257	9	Handle, extension, 3 in., $\frac{1}{2}$-in. dr.	1
257	10	Handle, extension, 3 in., $\frac{3}{8}$-in. dr.	1
257	11	Handle, extension, 8 in., $\frac{1}{2}$-in. dr.	2
254	1	Toolbox, Kennedy kit 522	1
254	2	Wrench, open end, $\frac{1}{2} \times \frac{9}{16}$ in.	1
254	3	Wrench, open end, $\frac{5}{8} \times \frac{9}{16}$ in.	1
254	4	Wrench, open end, $\frac{11}{16} \times \frac{5}{8}$ in.	1
254	5	Wrench, open end, $\frac{13}{16} \times \frac{3}{4}$ in.	1
254	6	Wrench, open end, $\frac{3}{4} \times \frac{7}{8}$ in.	2
254	7	Wrench, open end, $\frac{7}{8} \times 1$ in.	1
254	8	Wrench, crescent, 6 in.	1
254	9	Wrench, crescent, 8 in.	1
254	10	Wrench, crescent, 10 in.	1
254	11	Wrench, crescent, 12 in.	1
254	13	Wrench, crescent, 15 in.	1
254	14	Screwdriver, $\frac{1}{8} \times 2$ in.	1
254	15	Screwdriver, $\frac{3}{16} \times 3$ in.	1

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
254	16	Screwdriver, $\frac{5}{16} \times 6$ in.	1
254	17	Screwdriver, $\frac{3}{8} \times 8$ in.	1
254	18	Screwdriver, offset, $\frac{3}{4} \times 6\frac{1}{8}$ in.	1
254	19	Snapper	1
254	20	Gauge, thickness	1
254	21	Pliers, water pump, $9\frac{1}{2}$ in.	1
254	22	Pliers, slip joint, 6 in.	1
254	23	Pliers, vise grip, 7 in.	1
254	24	Pliers, vise grip, 10 in.	2
254	25	Pliers, diagonal cutter, 5 in.	1
254	26	Tape, 6 ft	1
254	27	Wrenches, Allen	2 sets
254	28	Plumb bob, mercury	1
256	1	Socket set, $\frac{1}{2}$-in. dr., $\frac{7}{16}$ to $1\frac{1}{4}$ in.	1
256	2	Socket set, $\frac{3}{8}$-in. dr., $\frac{5}{16}$ to $\frac{3}{4}$ in.	1
256	3	Socket set, $\frac{1}{4}$-in. dr., $\frac{5}{16}$ to $\frac{3}{4}$ in.	1
256	4	Socket set, $\frac{3}{4}$-in. dr., $1\frac{1}{2}$ to 2 in.	1
256	5	Speed wrench handle, $\frac{1}{2}$-in. dr.	1
256	6	Speed wrench handle, $\frac{3}{8}$-in. dr.	1
256	7	Ratchet wrench, $\frac{1}{2}$-in. dr.	2
256	8	Ratchet wrench, $\frac{3}{8}$-in. dr.	2
256	9	Handle, extension, 3 in., $\frac{1}{2}$-in. dr.	1
256	10	Handle, extension, 3 in., $\frac{3}{8}$-in. dr.	1
256	11	Handle, extension, 8 in., $\frac{1}{2}$-in. dr.	1
256	12	Ratchet wrench, $\frac{3}{4}$-in. dr.	1
284	1	Clips for X	251
284	2	CG determiner	1
284	3	Compression spring for X	1
284	4	Compression ring	1
284	5	Handles for can	4
284	6	Plates w/4 shackles for tie-down	2
284	7	Tie-down for can transport cradle	4
284	8	Scale, 2 ft	1
284	9	Brass welding rod, $\frac{1}{8}$ in.	2 lb
284	10	Steel welding rod, $\frac{1}{16}$ in.	1 lb
284	11	Grounding cables	5

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
284	12	Brazing flux	1 lb
284	13	Braided wire, 50 ft × $\frac{25}{32}$ in. for grounding strip	50 ft
284	14	Depth gauge attachment 468	1
284	15	Center punches, $\frac{3}{32}$ in.	6
284	16	Air wrench, $\frac{3}{8}$-in. size	1
277	1	Oil, high vacuum	2 qt
277	2	Tape, lead, pressure sensitive	3 rolls
277	3	Brush, varnish, 1 in.	2
277	4	Electrodes, $\frac{5}{32}$ in. eutectic 2101	5 lb
277	5	Electrodes, $\frac{1}{8}$ in. eutectic 2101	5 lb
277	6	Electrodes, $\frac{3}{16}$ in.	5 lb
277	7	Electrodes, $\frac{1}{8}$ in. eutectic 190	5 lb
277	8	Flux, eutectic	2 jars
277	9	Pins, cotter, $\frac{3}{32}$ × $1\frac{1}{4}$ in.	50
261	1	Trammel, 24 in.	1 set
261	2	Micrometer, 1 to 6 in.	1 set
261	3	Bars, boring	5
261	4	Straight edge, 48 in.	1
260	1	Universal surface gauge	1
260	2	Dial test indicator	1
260	3	Vernier depth gauge	1
260	4	Screw thread tool gauge	1
260	5	Center punches, machinist, 765C	6
260	6	Center punches, machinist, 765D	6
260	7	Center punches, machinist, 765E	6
260	8	Scriber, style 1	2
260	9	Scriber, style 2	2
260	10	Combination square w/protractor head	1
260	11	Toolbox, Kennedy kit	1
259	1	Plumb bob, mercury	2
259	2	Height gauge attachment	1
259	3	Comb, set, 12 in.	1
259	4	Micrometer caliper, 2 to 12 in.	1 set
259	5	Small hole gauge, $\frac{1}{8}$ to $\frac{1}{2}$ in.	1 set
259	6	Toolmakers button	1 set
259	7	Center gauge	2
259	8	Gauge, twist drill	1
259	9	Gauge, drill and steel wire	1
259	10	Spring dividers, B&S 800, 3 in.	2
259	11	Spring dividers, B&S 800, 4 in.	2
259	12	Spring dividers, B&S 800, 6 in.	1
259	13	Spring dividers, B&S 801, 3 in.	2
259	14	Spring dividers, B&S 801, 4 in.	2
259	15	Spring dividers, B&S 801, 6 in.	2

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
259	16	Spring dividers, B&S 802, 3 in.	2
259	17	Spring dividers, B&S 802, 4 in.	2
259	18	Spring dividers, B&S, 6 in.	2
259	19	Vernier caliper, B&S, 12 in.	1
259	20	Center and small hole attachment F/Calipers, B&S 573	1 set
259	21	Square, steel, B&S 573	1
259	22	Protractor, B&S 496	1
259	23	Blade, extra, 6 in.	1
259	24	Gauge, screw pitch	1
259	25	Tape, 100 ft steel	1
259	26	Gauge, wire 6 thickness	1
259	27	Reamers, A to Z	1 set
259	28	Reamers, 1 to 60	1 set
259	29	Everede boring tools	1 set
259	30	Pliers, vise grip	2
259	31	Pliers, side cutters	1
259	32	Wood tool kit	1
276	1	Drill, electric portable, $\frac{1}{2}$ in.	1
276	2	Drill, electric portable, $\frac{1}{4}$ in.	2
276	3	Sander, disk, portable, Stanley 77	1
276	4	Wheels, grinding, $6 \times \frac{1}{2}$ to 1 in.	4
267	1	Regulator, acetylene, two-stage, Airco 8409	2
267	2	Regulator, oxygen, two-stage, Airco 8401	2
267	3	Helmet, welding, arc	1
267	4	Hydraulic fluid	2 gal
267	5	Torch, welding, style 9903	1
267	6	Mixing head, style 9924	1
267	7	Tip, welding, style 89, size 1	1
267	8	Tip, welding, style 89, size 2	1
267	9	Tip, welding, style 89, size 3	1
267	10	Tip, welding, style 89, size 7	1
267	11	Tip, welding, style 89, size 9	1
267	12	Cutting attachment, style 9975	1
267	13	Cutting attachment tip, size 1	1
267	14	Goggles, welders	1 pr
267	15	Goggles, assembly speedframe	1 pr
267	16	Respirator, chemical cartridge	2
267	17	Facelet for respirator	25
267	18	Cartridge, replacement	20
267	19	Lenses, clear, cover 50	4 pr

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
267	20	Lenses, filter, glass	2 pr
269	1	Screws, cap, flathead, socket, 10-32, $\frac{3}{8}$ in.	2 bxs
269	2	Screws, cap, flathead, socket, 10-32, $\frac{1}{2}$ in.	2 bxs
269	3	Screws, cap, flathead, socket, 10-32, $\frac{5}{8}$ in.	2 bxs
269	4	Screws, cap, flathead, socket, 10-32, $\frac{3}{4}$ in.	2 bxs
269	5	Screws, cap, flathead, socket, 10-32, 1 in.	2 bxs
269	6	Screws, cap, flathead, socket, 10-32, $1\frac{1}{4}$ in.	2 bxs
269	7	Screws, cap, flathead, socket, 10-32, $1\frac{1}{2}$ in.	2 bxs
269	8	Screws, cap, flathead, socket, $\frac{1}{4}$-28, $\frac{3}{8}$ in.	2 bxs
269	9	Screws, cap, flathead, socket, $\frac{1}{4}$-28, $\frac{1}{2}$ in.	2 bxs
269	10	Screws, cap, flathead, socket, $\frac{1}{4}$-28, $\frac{5}{8}$ in.	2 bxs
269	11	Screws, cap, flathead, socket, $\frac{1}{4}$-28, 1 in.	2 bxs
268	1	Screws, cap, flathead, socket, $\frac{1}{4}$-28, $1\frac{1}{4}$ in.	2 bxs
268	2	Screws, cap, flathead, socket, $\frac{1}{4}$-28, $1\frac{1}{2}$ in.	2 bxs
268	3	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $\frac{3}{8}$ in.	2 bxs
268	4	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $\frac{1}{2}$ in.	2 bxs
268	5	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $\frac{5}{8}$ in.	2 bxs
268	6	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $\frac{3}{4}$ in.	2 bxs
268	7	Screws, cap, flathead, socket, $\frac{5}{16}$-24, 1 in.	2 bxs
268	8	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $1\frac{1}{4}$ in.	2 bxs
268	9	Screws, cap, flathead, socket, $\frac{5}{16}$-24, $1\frac{1}{2}$ in.	2 bxs
268	10	Screws, cap, flathead, socket, $\frac{3}{8}$-24, $\frac{1}{2}$ in.	2 bxs
268	11	Screws, cap, flathead, socket, $\frac{3}{8}$-24, $\frac{5}{8}$ in.	2 bxs
268	12	Screws, cap, flathead, socket, $\frac{3}{8}$-24, $\frac{3}{4}$ in.	2 bxs
268	13	Screws, cap, flathead, socket, $\frac{3}{8}$-24, 1 in.	2 bxs
268	14	Screws, cap, flathead, socket, $\frac{3}{8}$-24, $1\frac{1}{4}$ in.	2 bxs
268	15	Screws, cap, flathead, socket, $\frac{3}{8}$-24, $1\frac{1}{2}$ in.	2 bxs
268	16	Screws, cap, flathead, socket, $\frac{1}{2}$-20, $\frac{3}{4}$ in.	2 bxs
268	17	Screws, cap, flathead, socket, $\frac{1}{2}$-20, 1 in.	2 bxs
265	1	Cords, extension, 50 ft, complete w/connections	4
265	2	Clips, shower curtain	144
265	3	Hoses, welding, 25 ft	2
265	4	Cable bracket for "C"	3 sets
262	1	Arms, hoisting, X and B	1 set
262	2	Arms, hoisting, Silex	1 set
262	3	Rods, stabilizing, X and B	2 sets
262	4	Rods, stabilizing, H	2 sets
262	5	Slings, X-unit	2
200	1	Toolbox, steel, Kennedy kit 520	2

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
216	1	Portable work table w/casters and brakes	1
202	1	Tape, scotch, lead foil, 2 × 1296 in.	8 rolls
201	1	Tape, scotch, lead foil, 2 × 1296 in.	8 rolls
247	1	Putty, glazing	11
243	1	"C" tower tie-downs w/anchor bkts. 8 rods 4 turnbuckles	1
283	1	Stool, 2 step	1
283	2	Clevis	2
283	3	Hook adaptors	3
279	1	Clip boards	9
279	2	Pans, dust	3
279	3	Box, transparent w/compartment	3
279	4	Brush, counter	3
279	5	Brush, floor, 18 in.	4
279	6	Tool, weld cleaning	1
279	7	Handles for brooms	5
214-1	1	Glass jug for water cooler	1
214	1	Water cooler	1
213	1	Safe file, 2 drawer, 3 comb.	1
212	1	Refrigerator, 5 cu ft (Westinghouse)	1
281	1	Adding machine, Burroughs	1
264	1	H-2 gear complete w/hose	1
263	1	Vacuum pump, Central Scientific	1
303	1	Vacuum pump, power	1
206	1	Strongback	1
206	2	Hoisting arms, [redacted]	1 set
206	3	Hoisting arms, [redacted]	1 set
207	1	Hoist beams, brackets, and pins [redacted]	1 set
207	2	Stabilizing fittings, [redacted]	1 set
208	1	Hoist beams, brackets, and pins, [redacted]	1 set
208	2	Stabilizing fittings, [redacted]	1 set
209	1	Sling, rotating, [redacted]	1
210	1	Sling, rotating, [redacted]	1
211	1	Cradle, transport, [redacted]	1
220	1	Cradle, transport, [redacted]	1
215	1	Firing stand, [redacted]	1
227	1	Firing stand, [redacted]	1
215-1	1	[redacted] tower tie-downs	1 set
215-1	2	[redacted] transport cradle tie-downs	1 set
215-1	3	[redacted] stabilizing rods	1 set
270	1	[redacted] spares	1
231	1	"C" lab stand	1

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
231	2	Stabilizing rods	4
232	1	Sling, assy. for "C" crate, complete	1
233	1	Saddles (2 pcs.)	1 set
233	2	Arms, lifting, strongback	2
233	3	Beams, lifting, complete	2
234	1	Mount, X-unit	1
234	2	Cover can for X-unit, complete w/angles	1
236	1	X-unit support for "C" No. 1	1
236	2	X-unit cover w/angles for "C"	1
237	1	X-unit support for "C"	1
237	2	X-unit cover w/angles for "C"	1
238	1	Slings for crate f/X or B	1 set
241	1	Slings for crate (H)	1
242	1	X or B lab stand (KD)	1
244	1	Saddles F/C 1	1
245	1	Saddles F/C 2	1
246	1	H lab stand (XD)	1
248	1	Trough for X and B	1
249	1	Trough for X and B	1
250-1	1	H firing stand	1
250-2	1	Track for H firing stand	1
251-1	1	Firing stand, X and B	1
251-2	1	Track for X and B firing stand	1
271	1	F/stand F/X or B (spare)	1
272	1	F/stand F/H (spare)	1
274	1	Track for H, X, or B F/stand	1
275	1	Sling, positioning, F/X or B	2
278	1	Tower roller skates	2
278	2	Trunnion beams for "C"	2
229	1	Strongback	1
222	1	Strongback	1
223	1	Booster, F/stand	1
218	1	Support, sphere	1
228	1	Tower security covers w/wood supports	1
205	1	Hoist, 6 ton, Chisholm-Moore	1
204	1	A frame, complete w/hardware	1

SHIPPING MANIFEST
Organization 3.1.4.2

Box No.	Item No.	Description	Quantity
*288	1	Lot 40 T IDD 559	1
*287	1	Lot 40 T IDD 559	1
*221	1	Trailer, wishbone	1
*285	1	Cover, security, wishbone trailer w/frames	2
*280	1	Cover, security, F/A frame	1
*266	1	Split-band spreaders	2
*266	2	C Clamps, 8 in.	2
*266	3	Grease gun, Alemite 4014	1
*266	4	Crowbars, 36 in.	2
*266	5	Crowbars, 18 in.	1
*253	1	Hoist, 6 ton, Chisholm-Moore	1
*252	1	A frame (main A)	1
*235	1	Scale, crane, 20,000 lb cap.	1
*226	1	Dolly, front case	1
*225	1	Dolly, rear case	1
*224	1	Dolly, split band	1
*217	1	Wedges	4
*282	1	Drill set, HS steel, 1 to 60	2 sets
*282	2	Spare nuts and washers for fins	1 set
*291	1	BUS, box	1 can
*290	1	BUS, box	1 can
*289	1	BUS, box	1 can
*240	1	BOS 1 of 3	1
*239	1	BOS 1 of 3	1
*230	1	BOS 2 of 3	1
*219	1	BOS 2 of 3	1

*Items which were procured, packaged, and shipped for the Air Drop (King Shot) phase of Greenhouse. Most of these items were returned to Sandia from Port of Chicago.

Note: [redacted] and four inert ballisti[redacted] bombs were also returned to Sandia from Port of Chicago. Total weight of bombs and equipment returned when King Shot was canceled was approximately 110,000 lb.

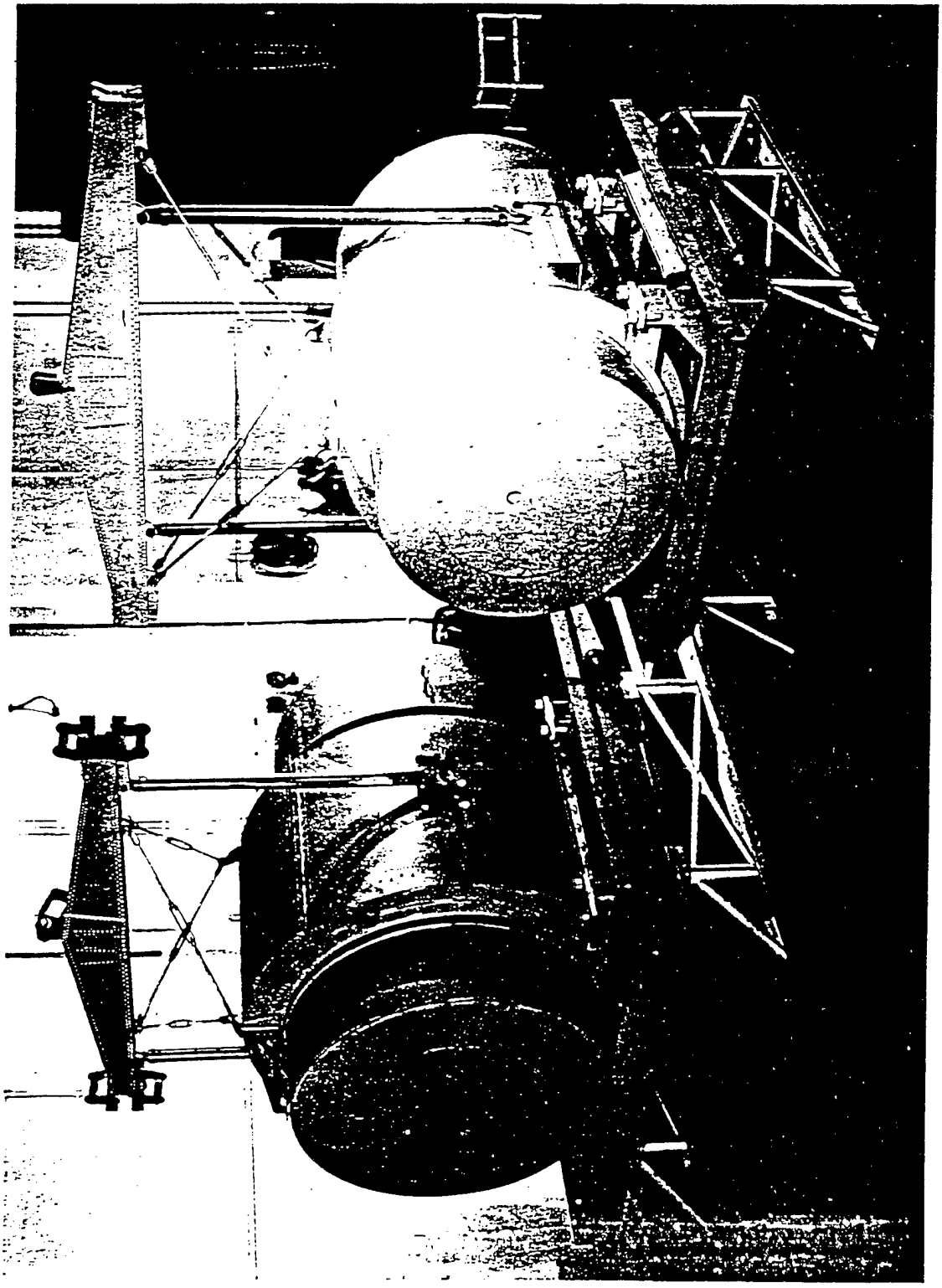

Fig. 2.1 Size Comparison

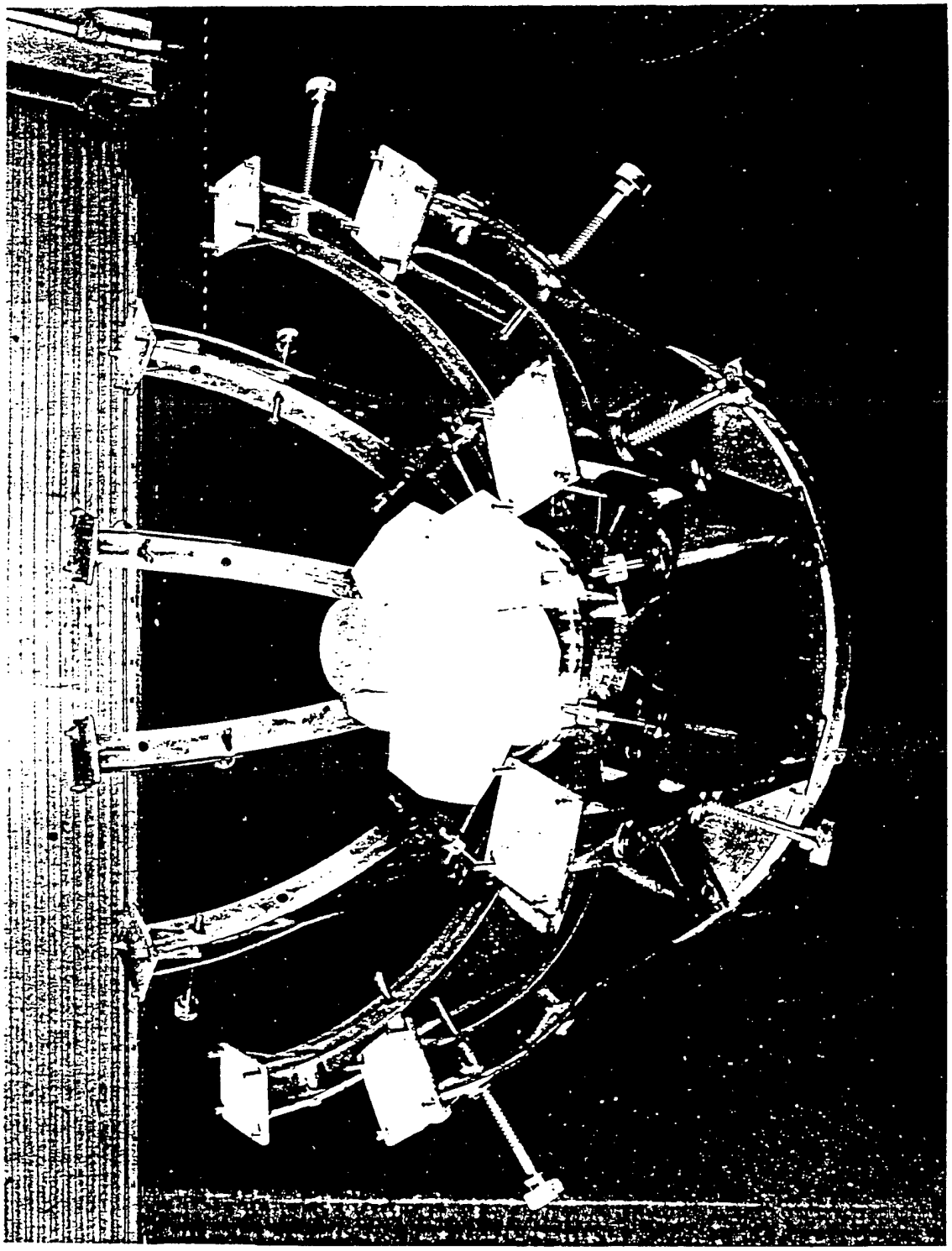

Fig. 2.2 [redacted] Assembly Fixture with Alignment Lens Cluster

Pages 41 through 55 are deleted.

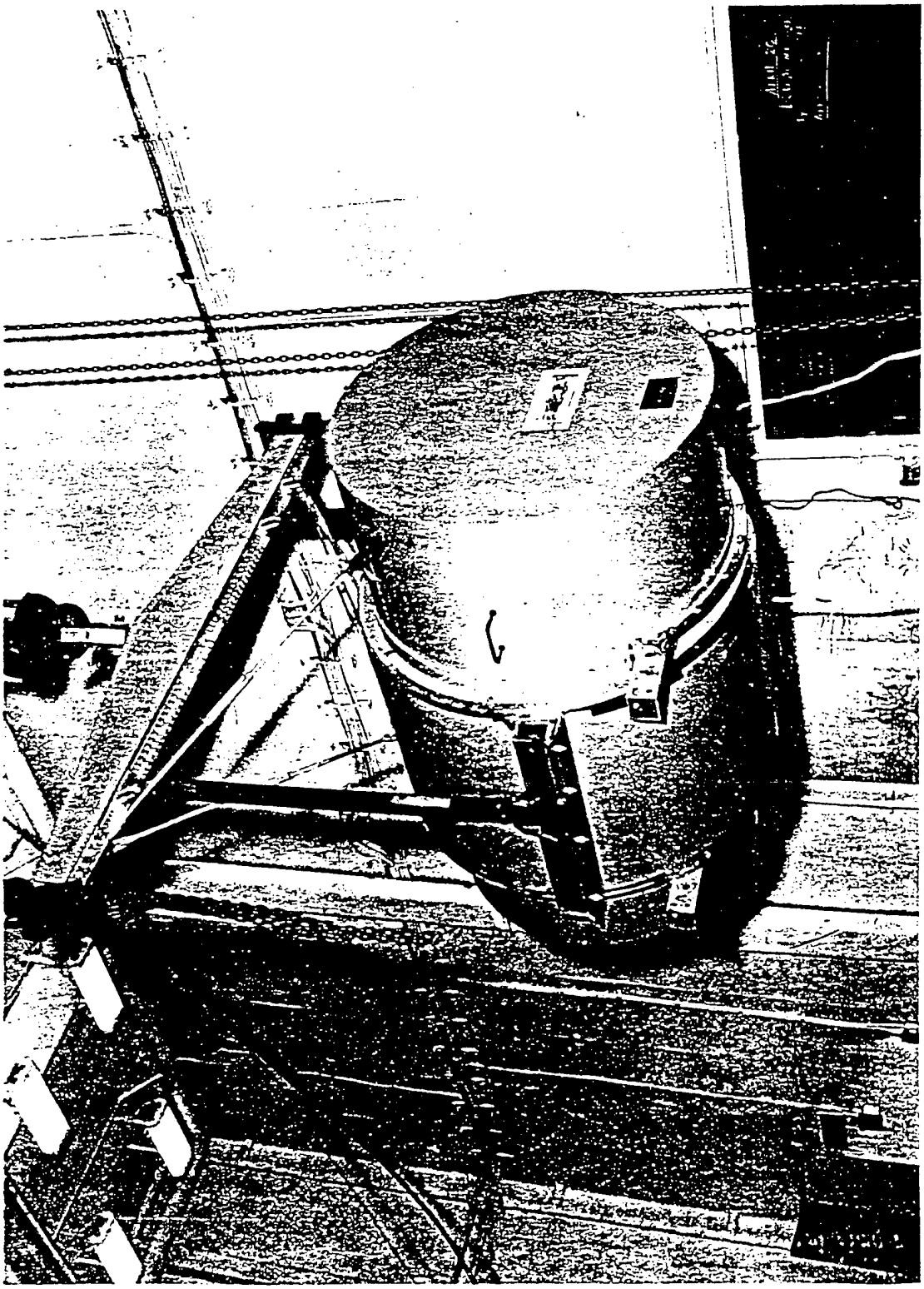

Fig. 2.18 Box-type Support Beam

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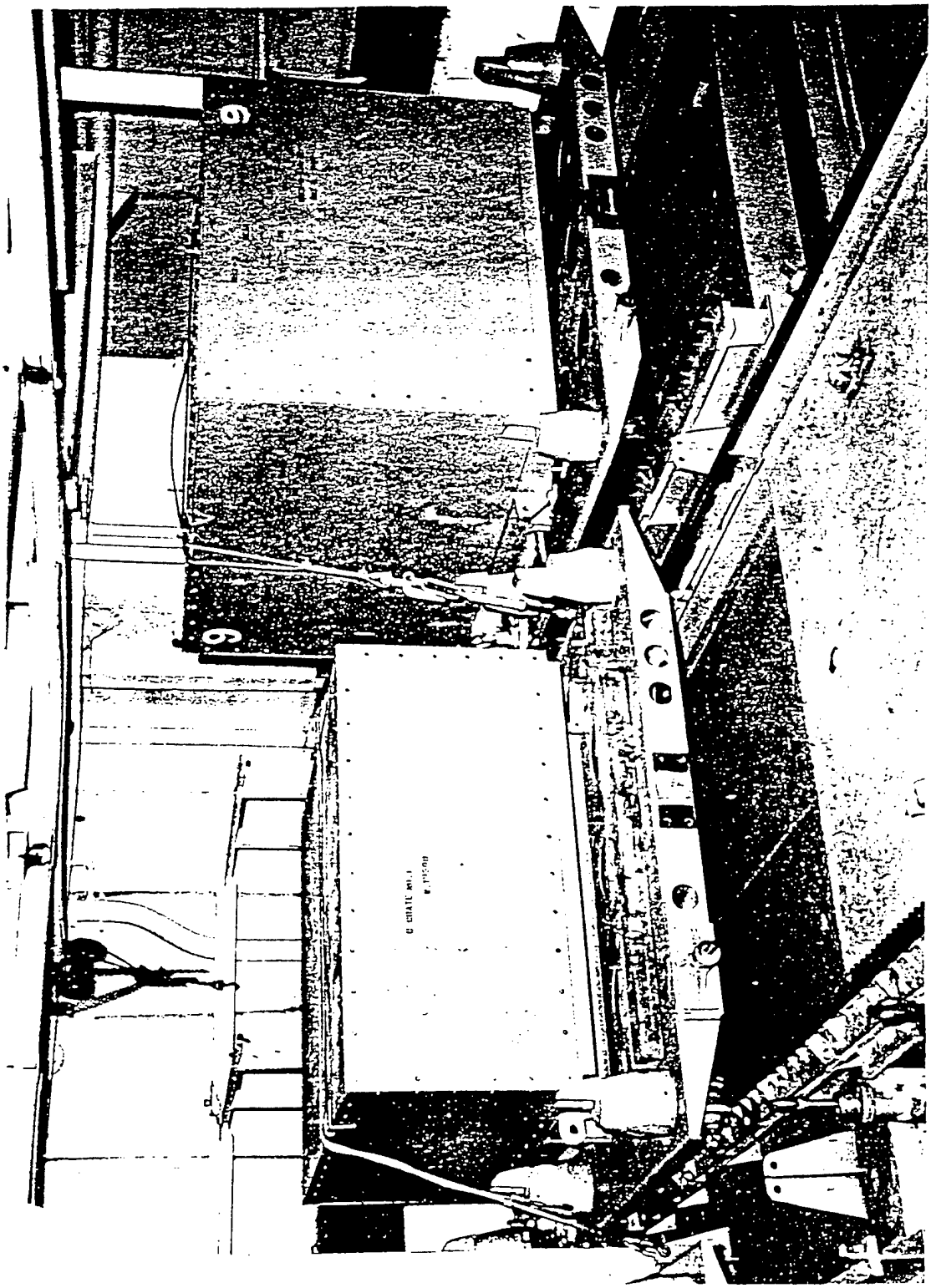

Fig. 3.6 Storage Space, Shop 18

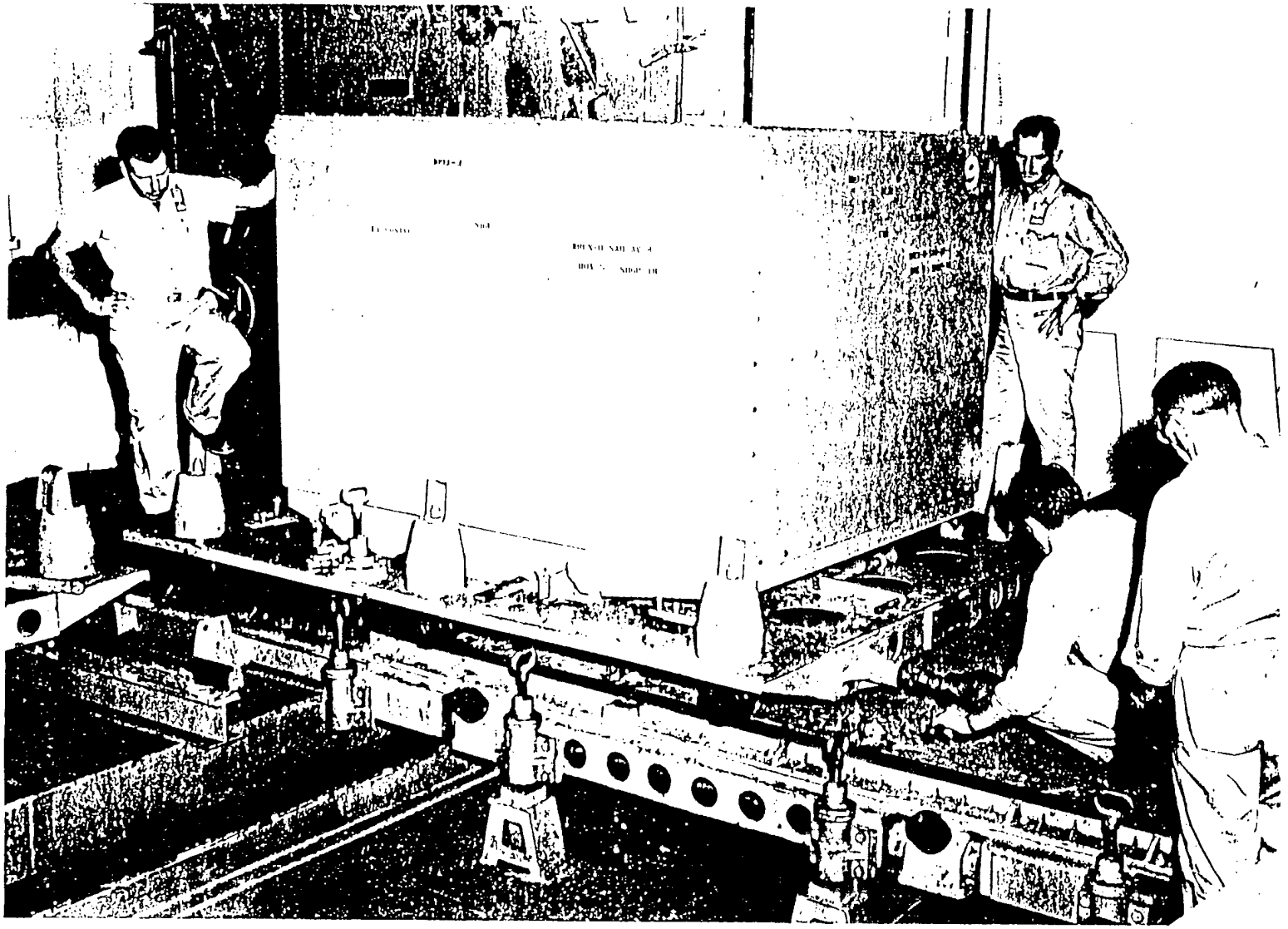

Fig. 3.7 [redacted] from Storage Space to Elevator Dolly; Elevator Well Visible

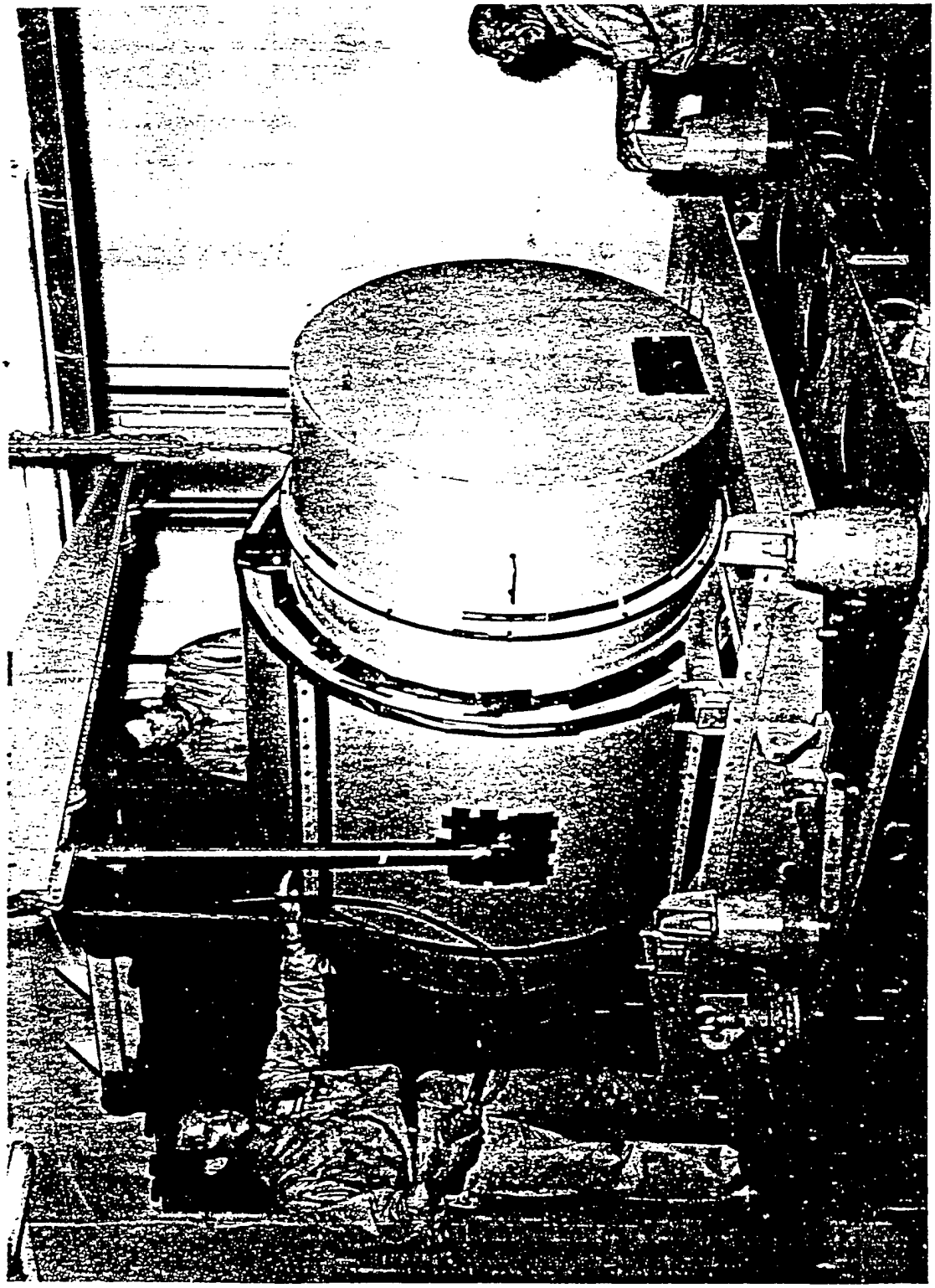

Fig. 3.8 Lifting Unit from Crate Base

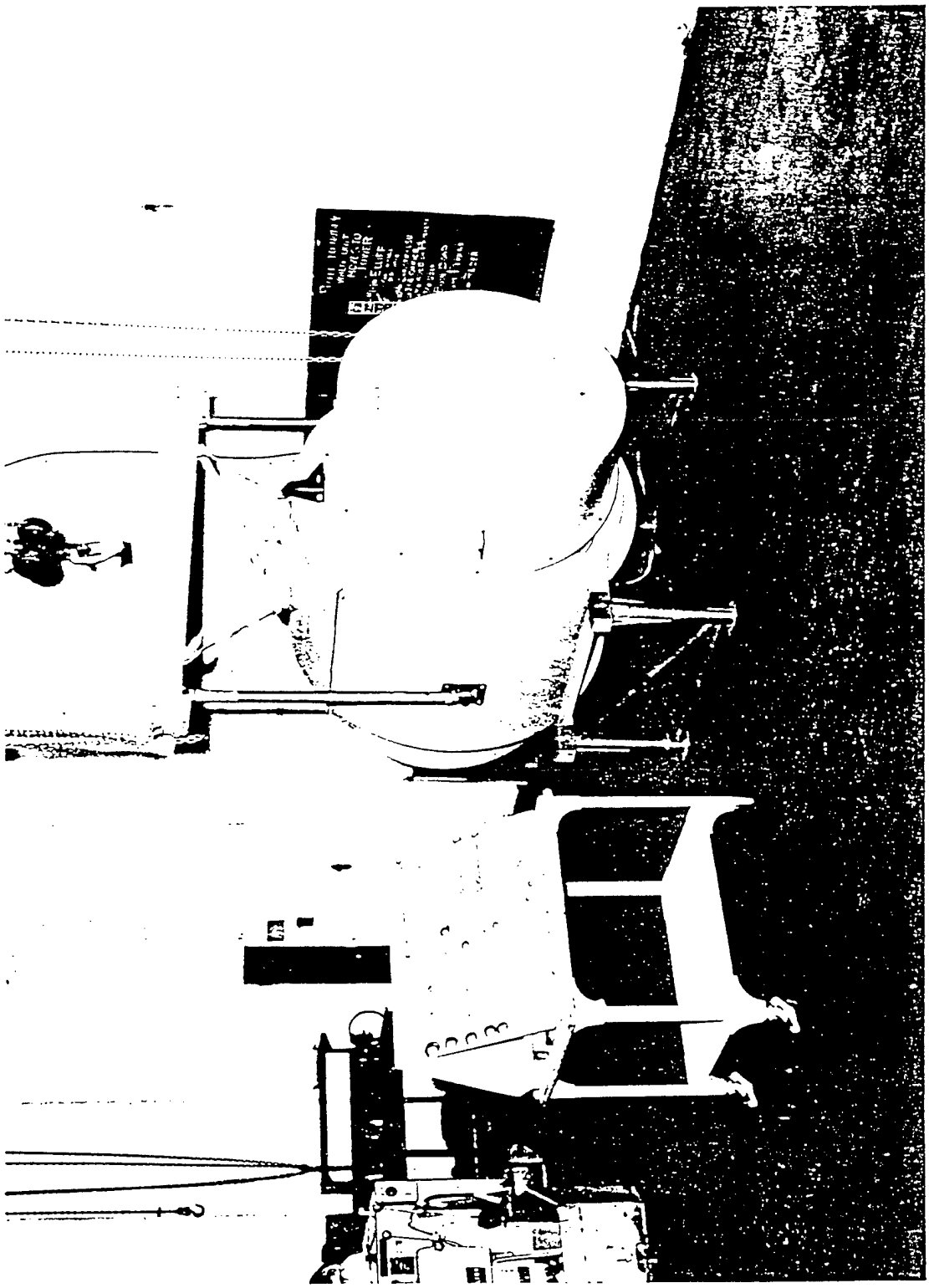

Fig. 3.9 Unit on Lab Stand

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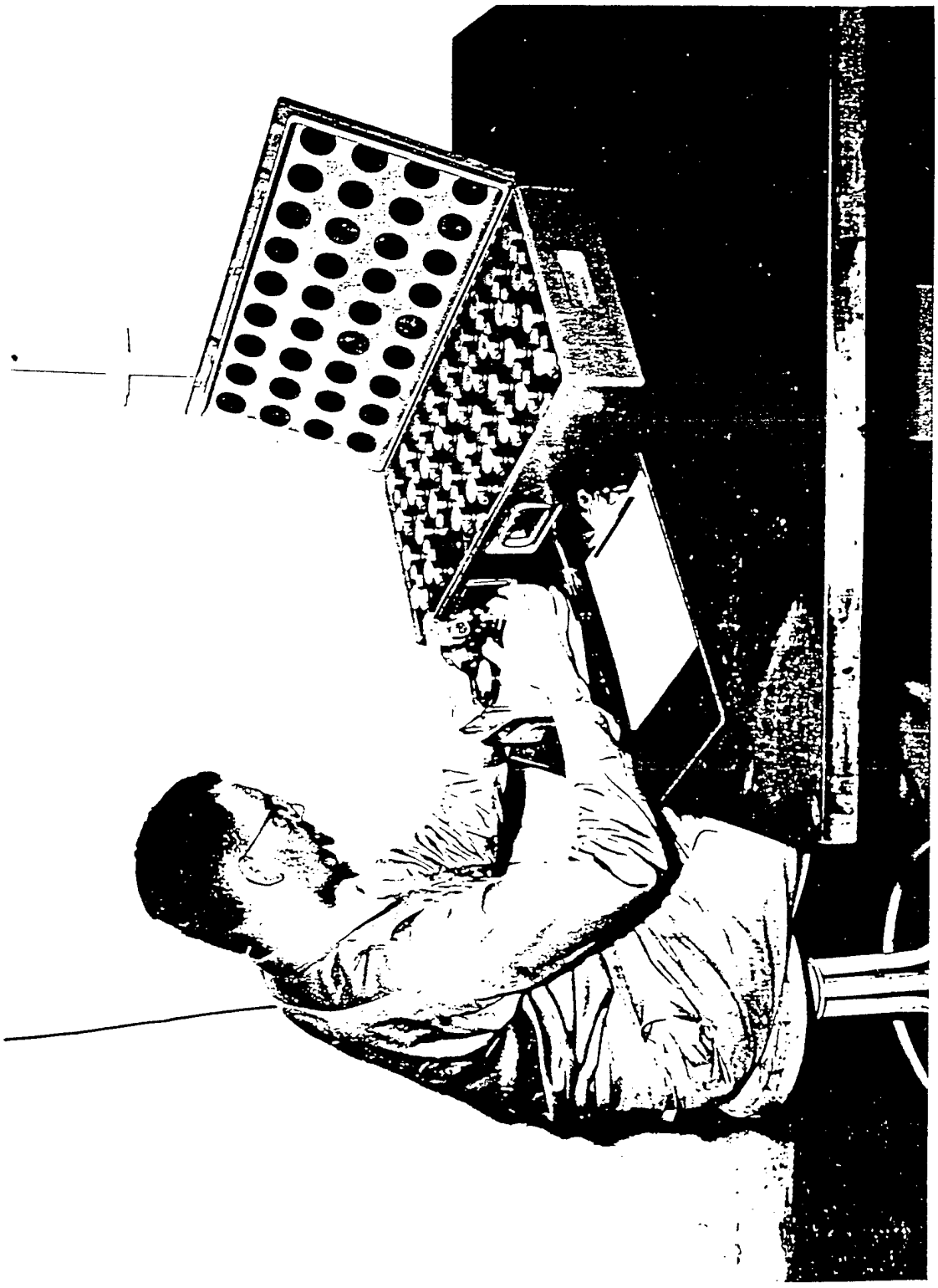

Fig. 3.14 Checking Detonators

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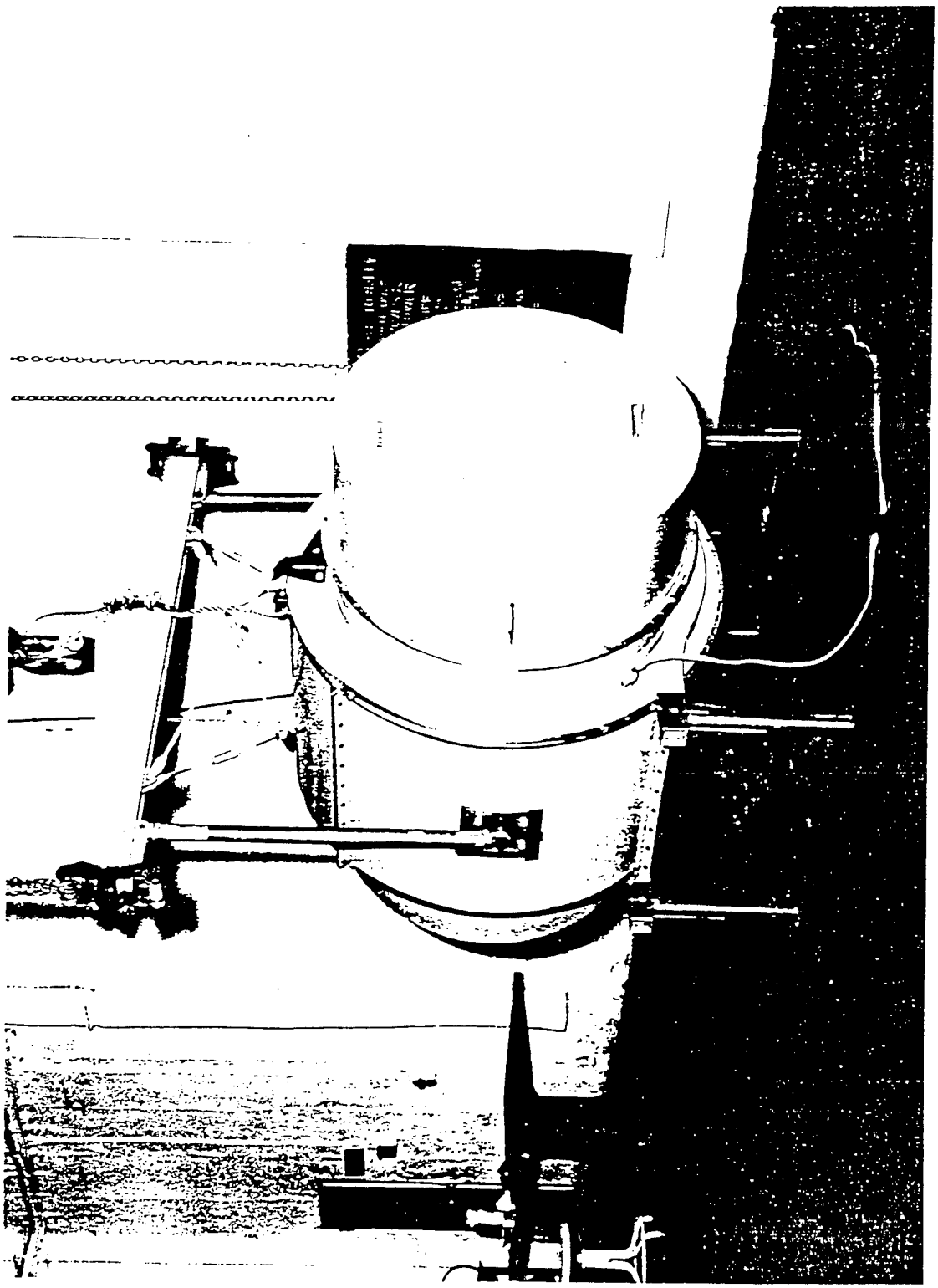

Fig. 3.19 Unit Sealed; Strongback and Stabilizing Arms Installed

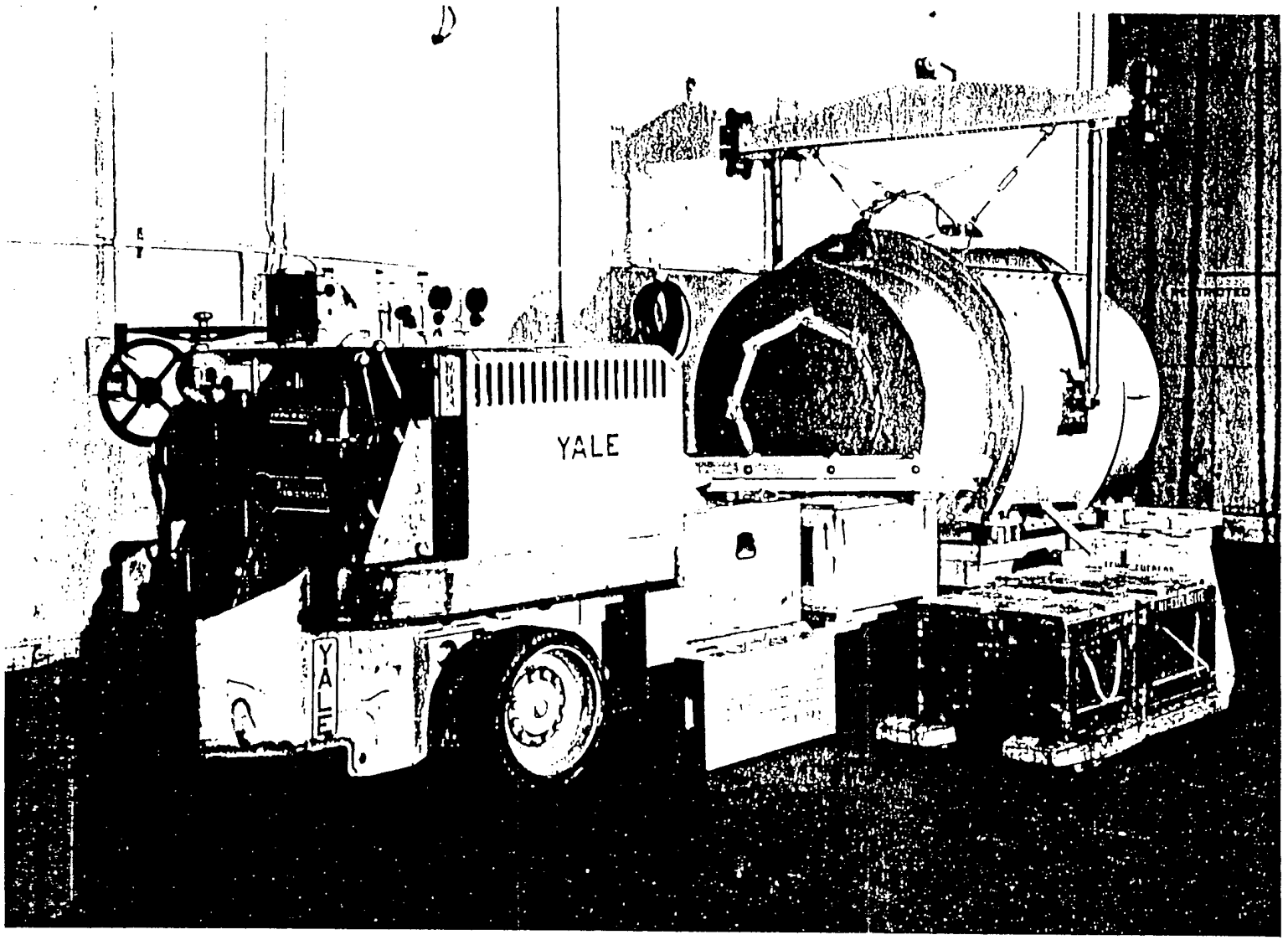

Fig. 3.20 Completed Unit on Electric Lift Truck with Associated Equipment

Fig. 3.21 LSU 15 Preparing To Tie Up alongside AV-4

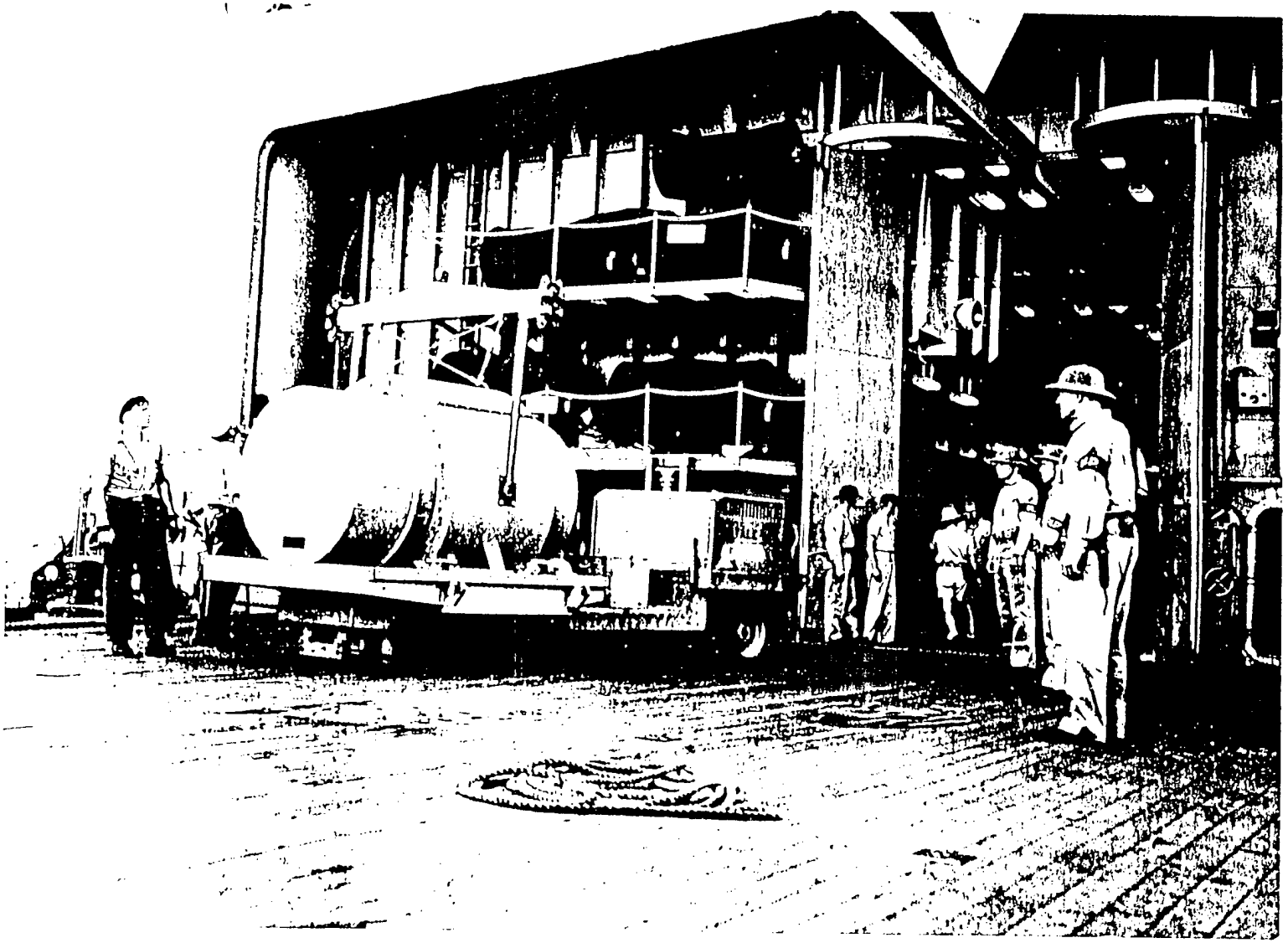

Fig. 3.22 Unit and Equipment Removed from Shop 1

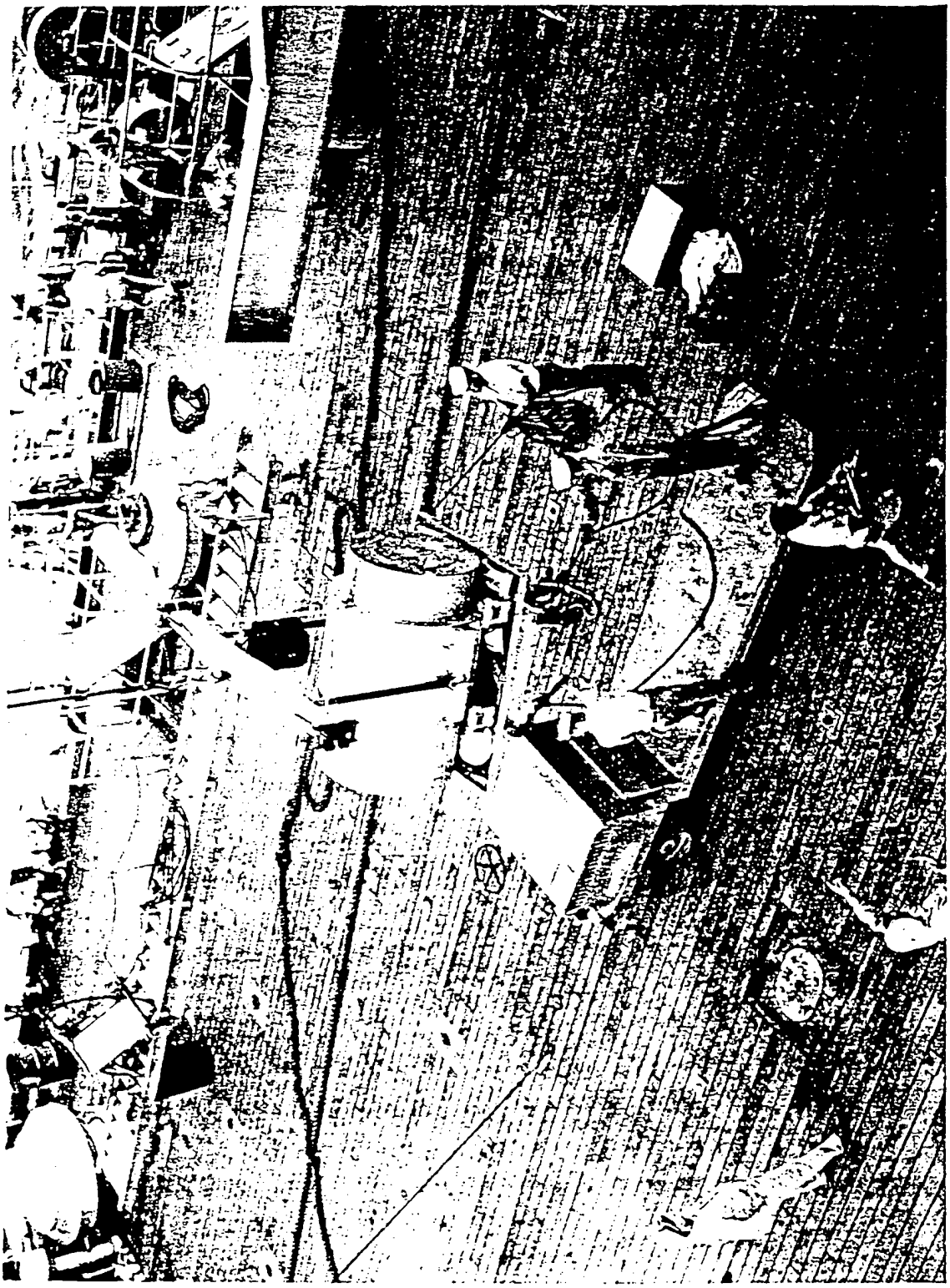

Fig. 3.23 Hoisting Unit Clear of Lift Truck

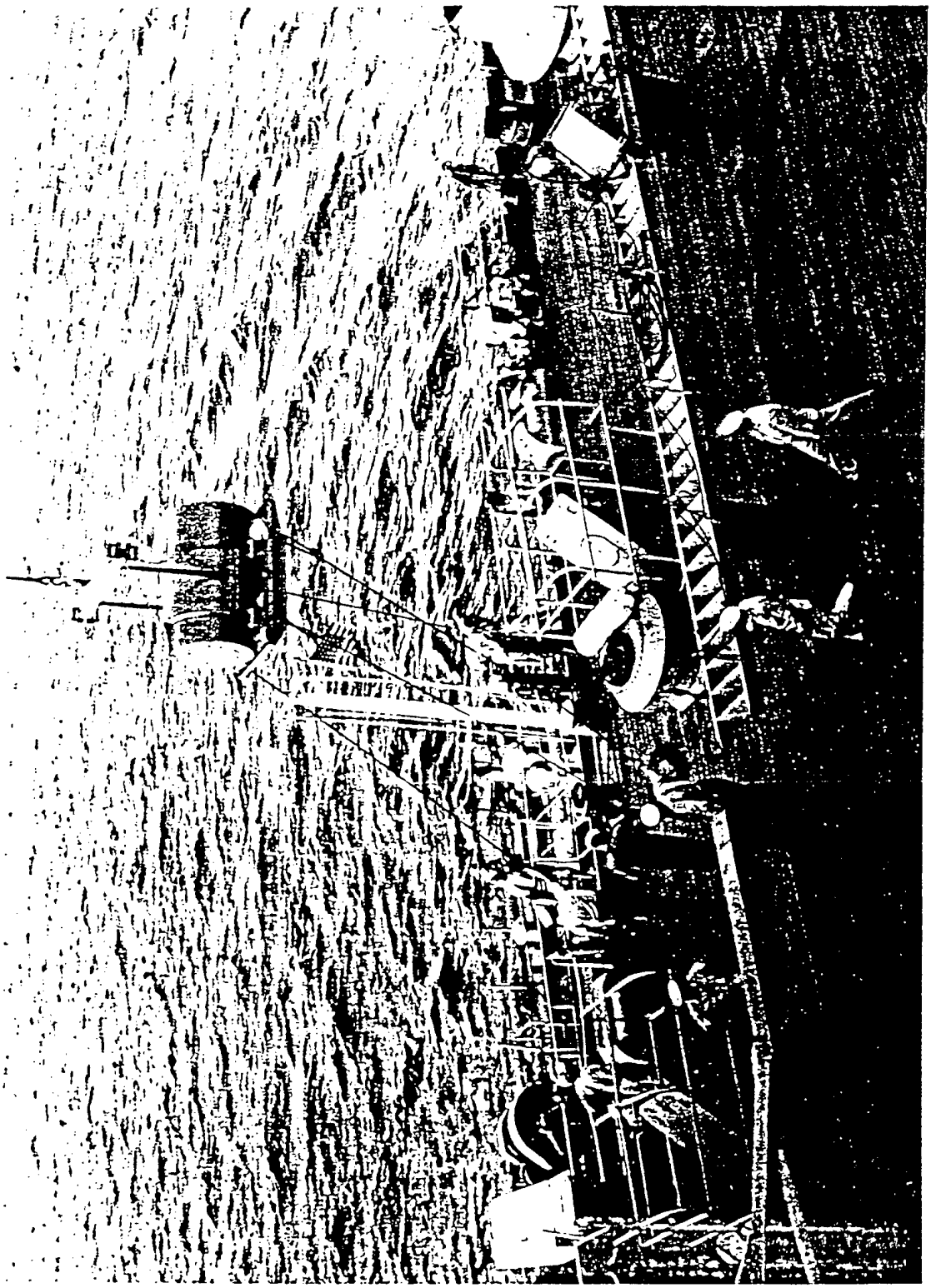

Fig. 3.24 Lowering Unit Aboard LSU 15

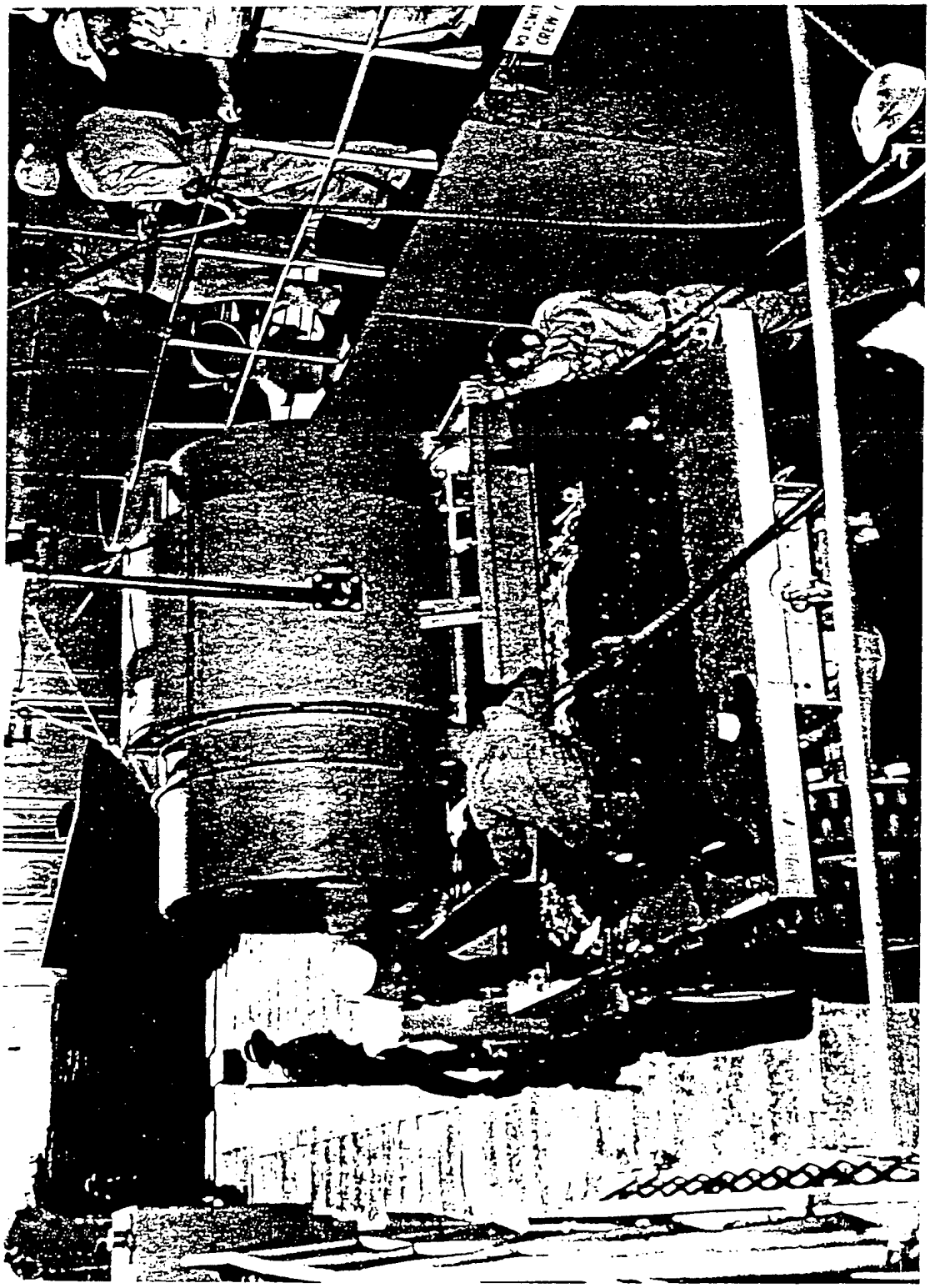

Fig. 3.25 Positioning Unit on Truck Bed

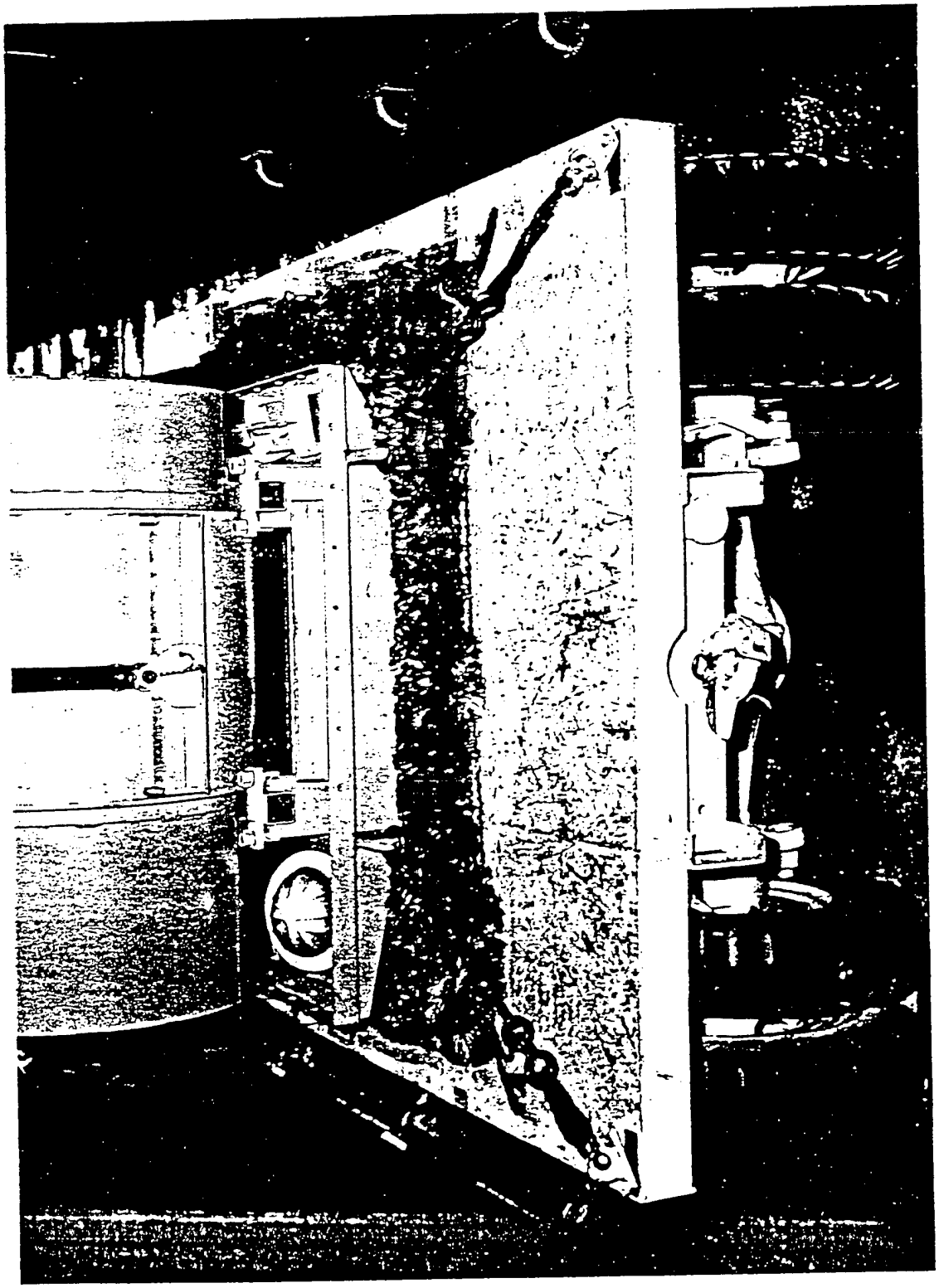

Fig. 3.26 Tie-downs Used To Secure Crate Base to Truck

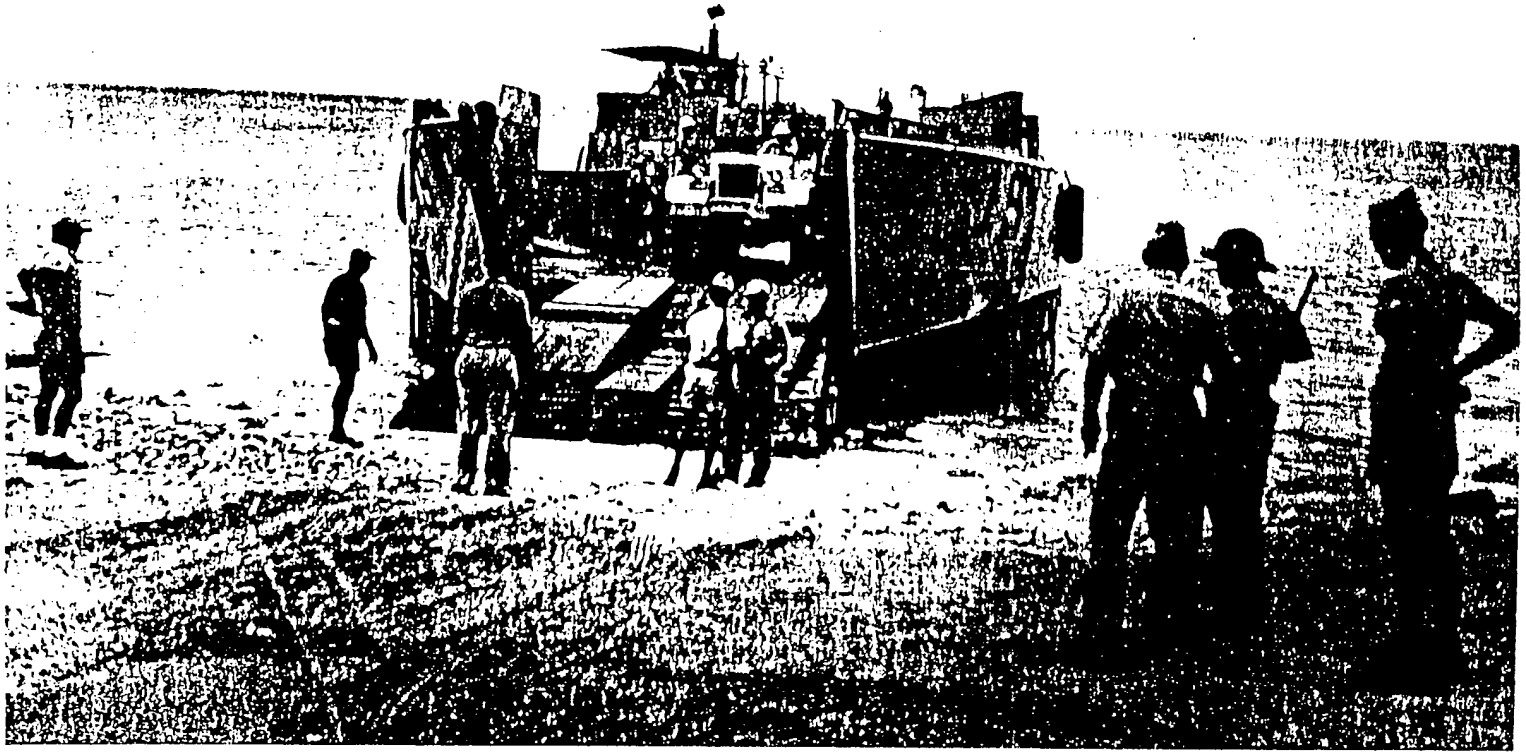

Fig. 3.28 LSU Beached and Ramp Lowered

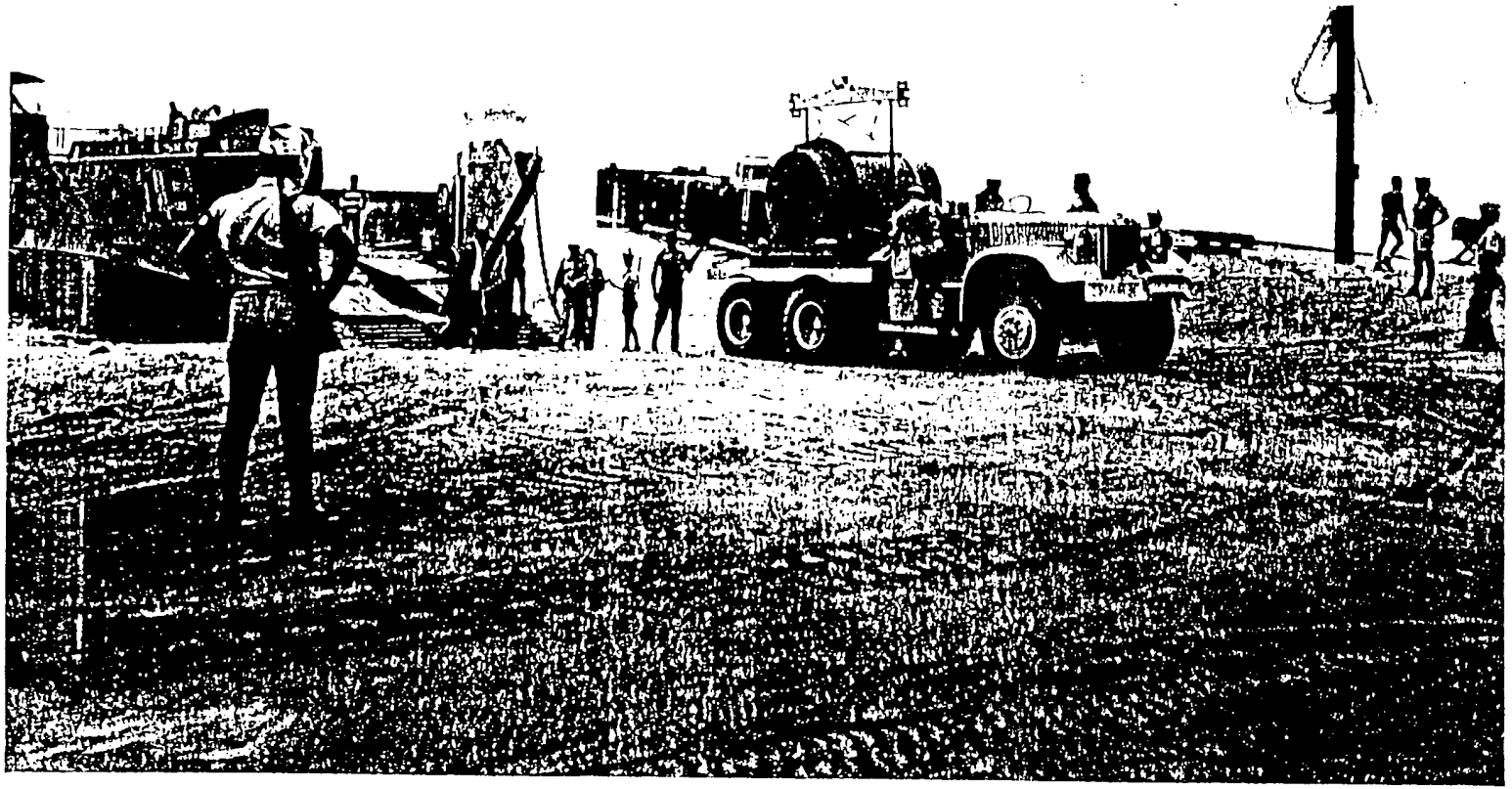

Fig. 3.29 Truck on Beach, Enroute to Tower

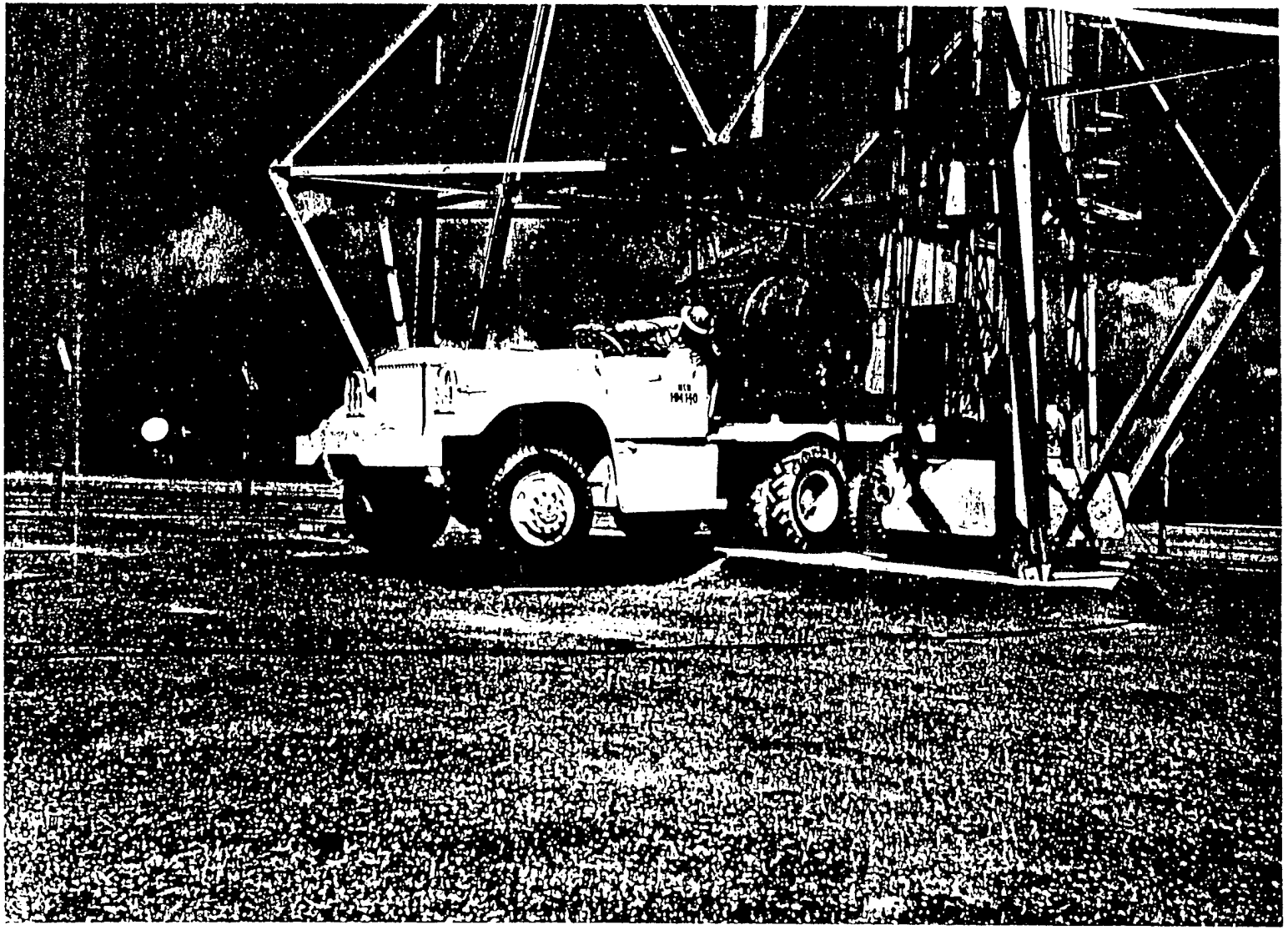

Fig. 3.30 Bomb Truck Backing into Position at Base of Tower

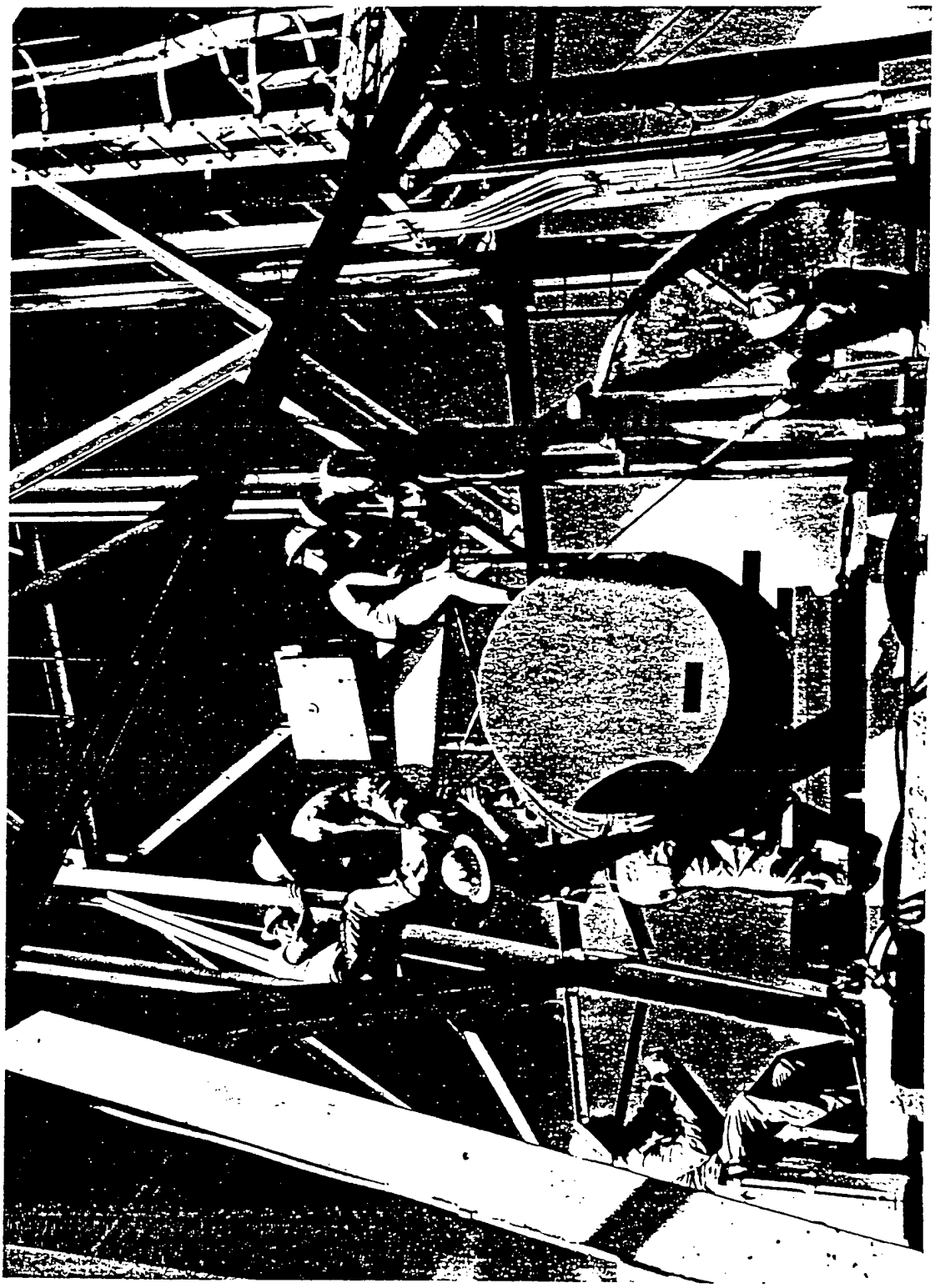

Fig. 3.31 Engaging Rail Grippers on Guide Rails

Fig. 3.32 Engaging Roller Skates on Guide Rails

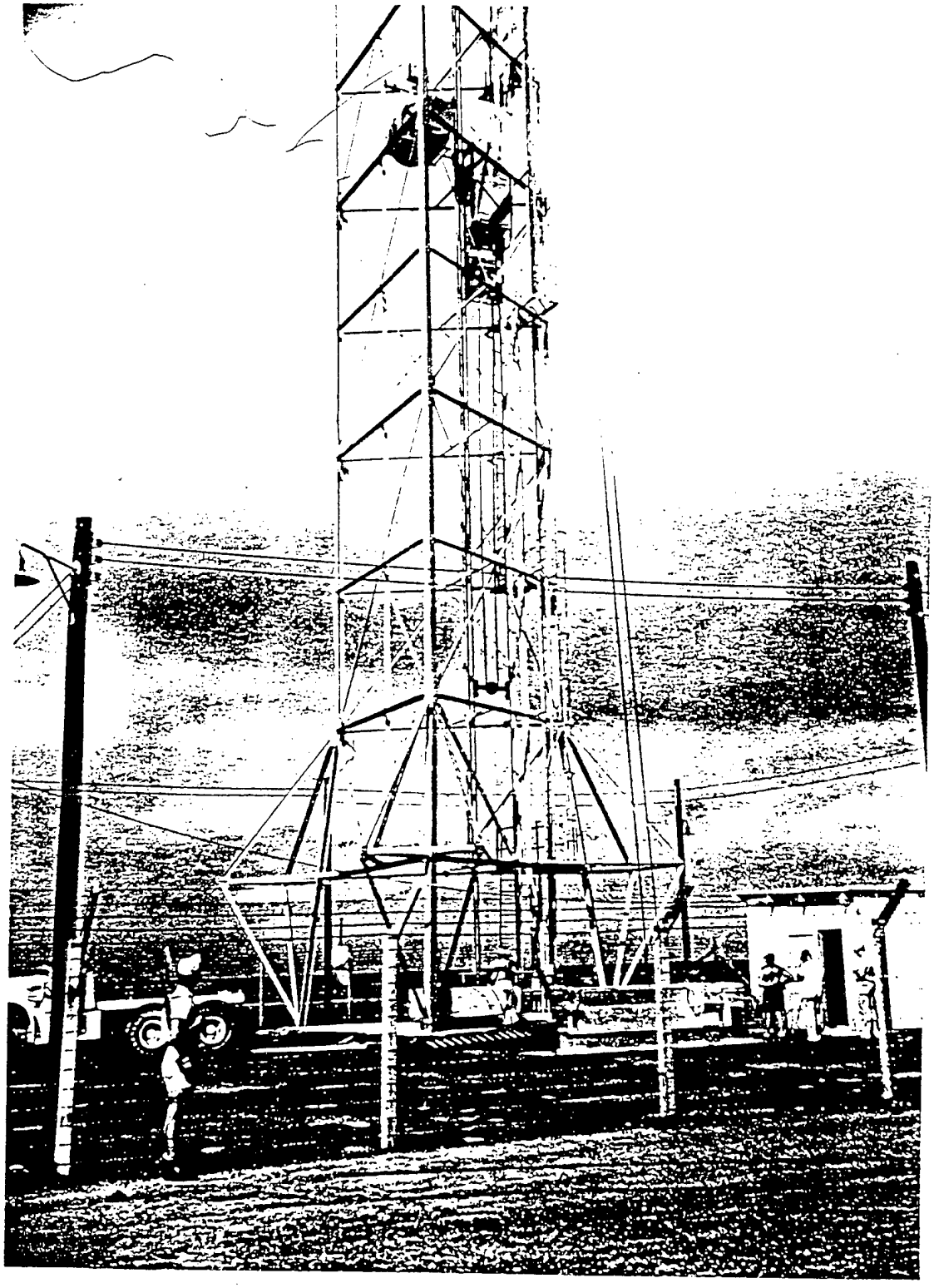

Fig. 3.33 Tower Ascent Started

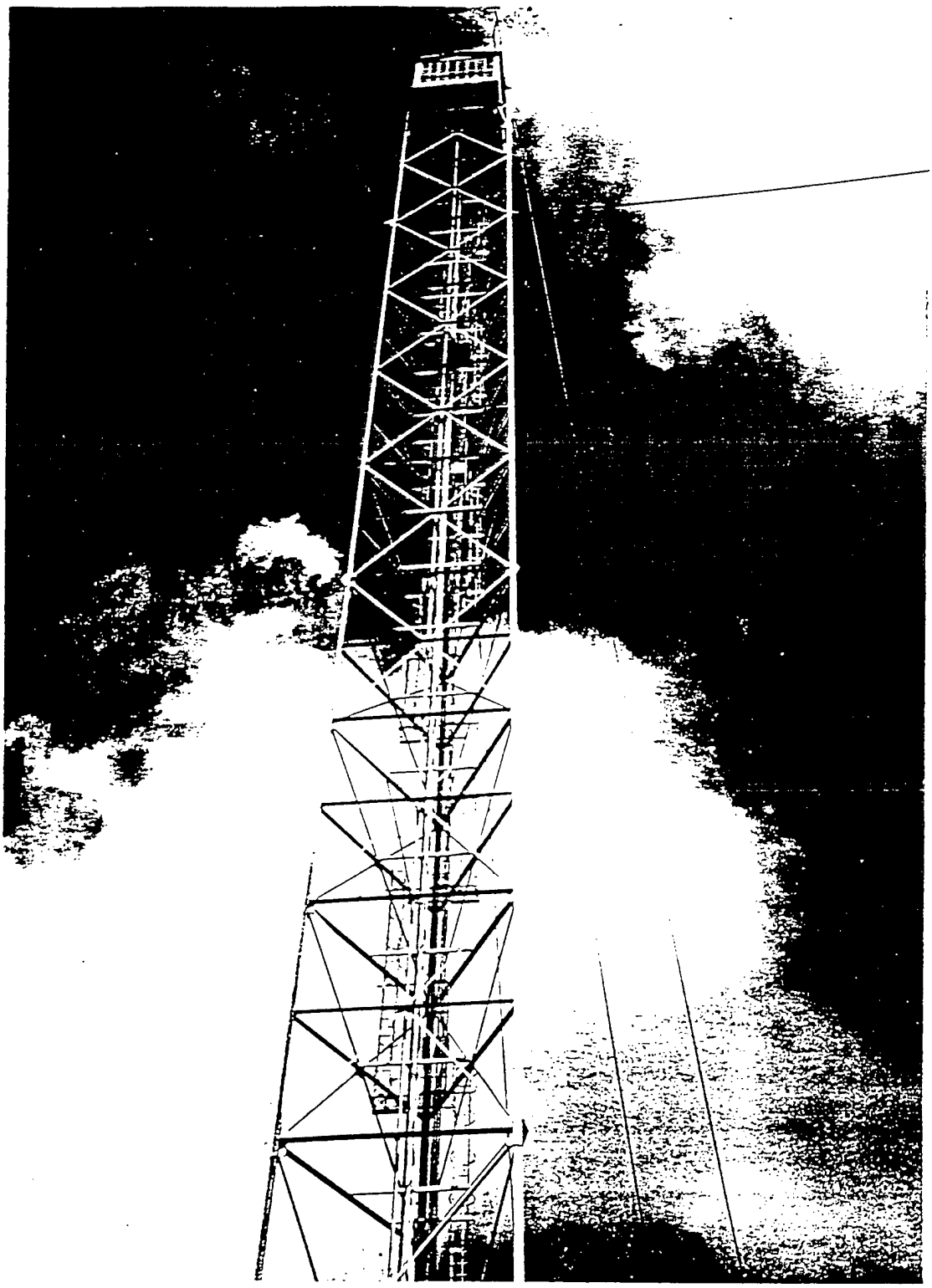

Fig. 3.34 Unit Nearing Tower Cau; Trap-door Opening Visible

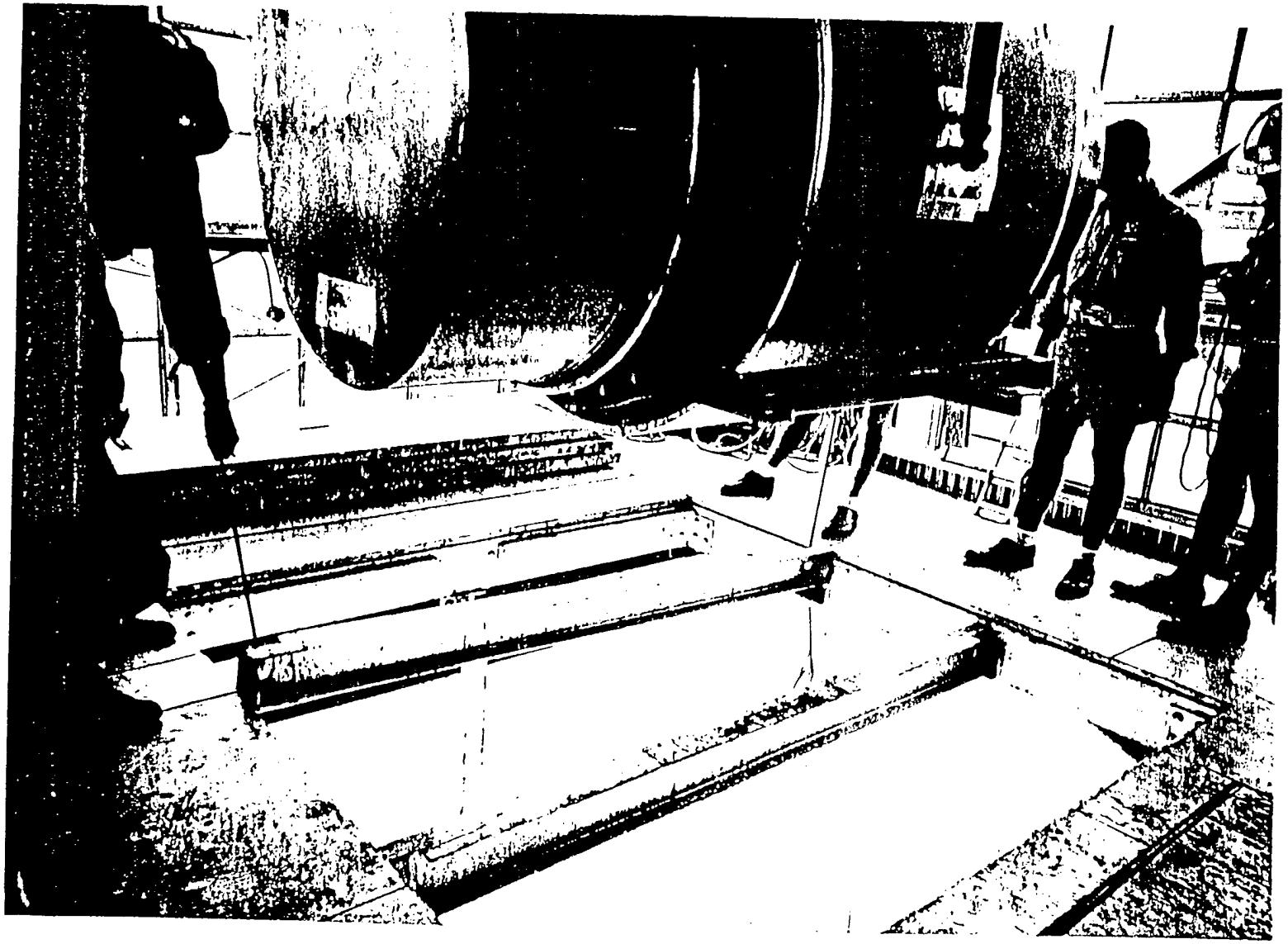

Fig. 3.35 Unit in Tower Cab; Replacing Removable Floor Beams

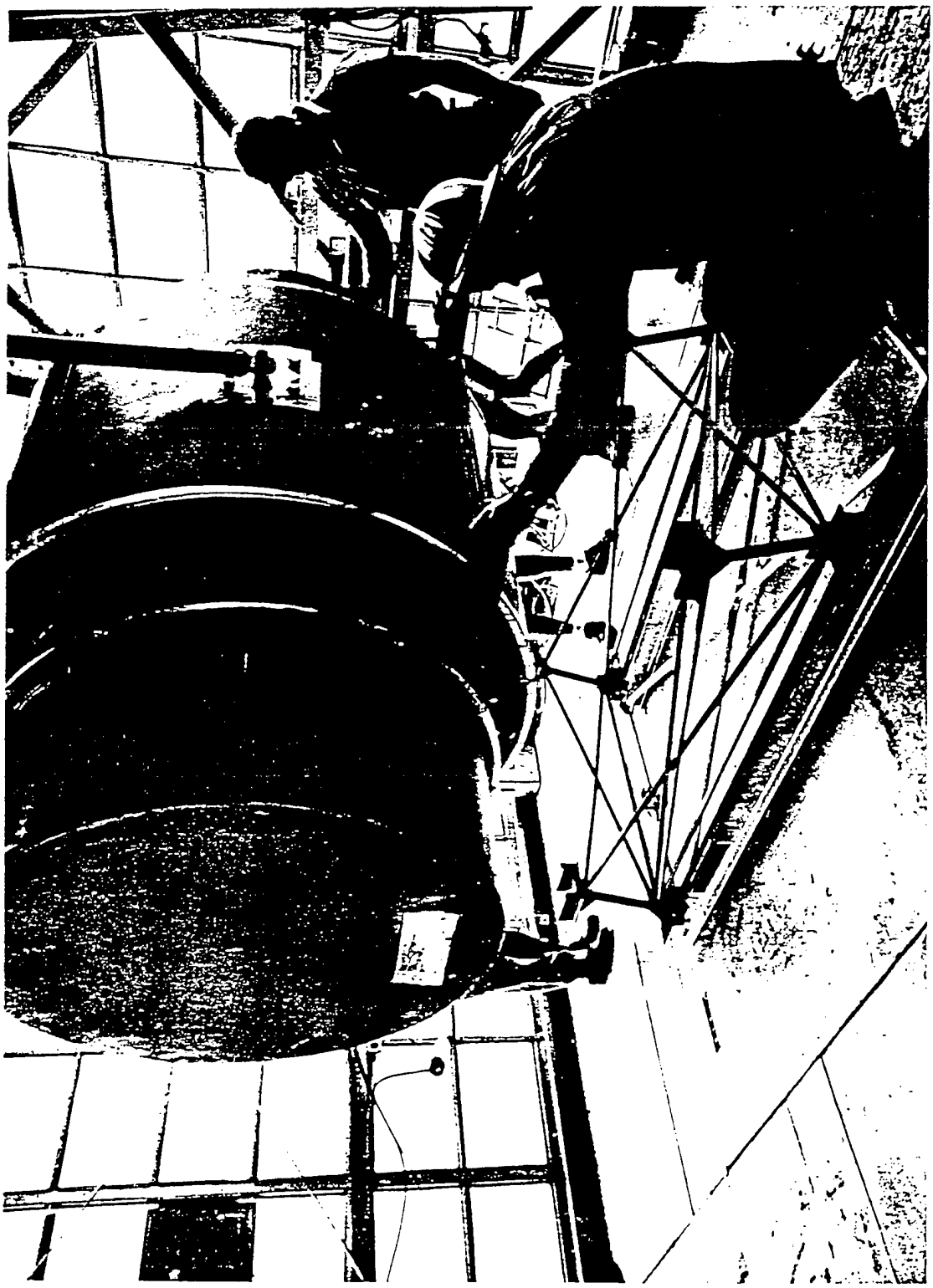

Fig. 3.36 Lowering Unit onto Firing Stand

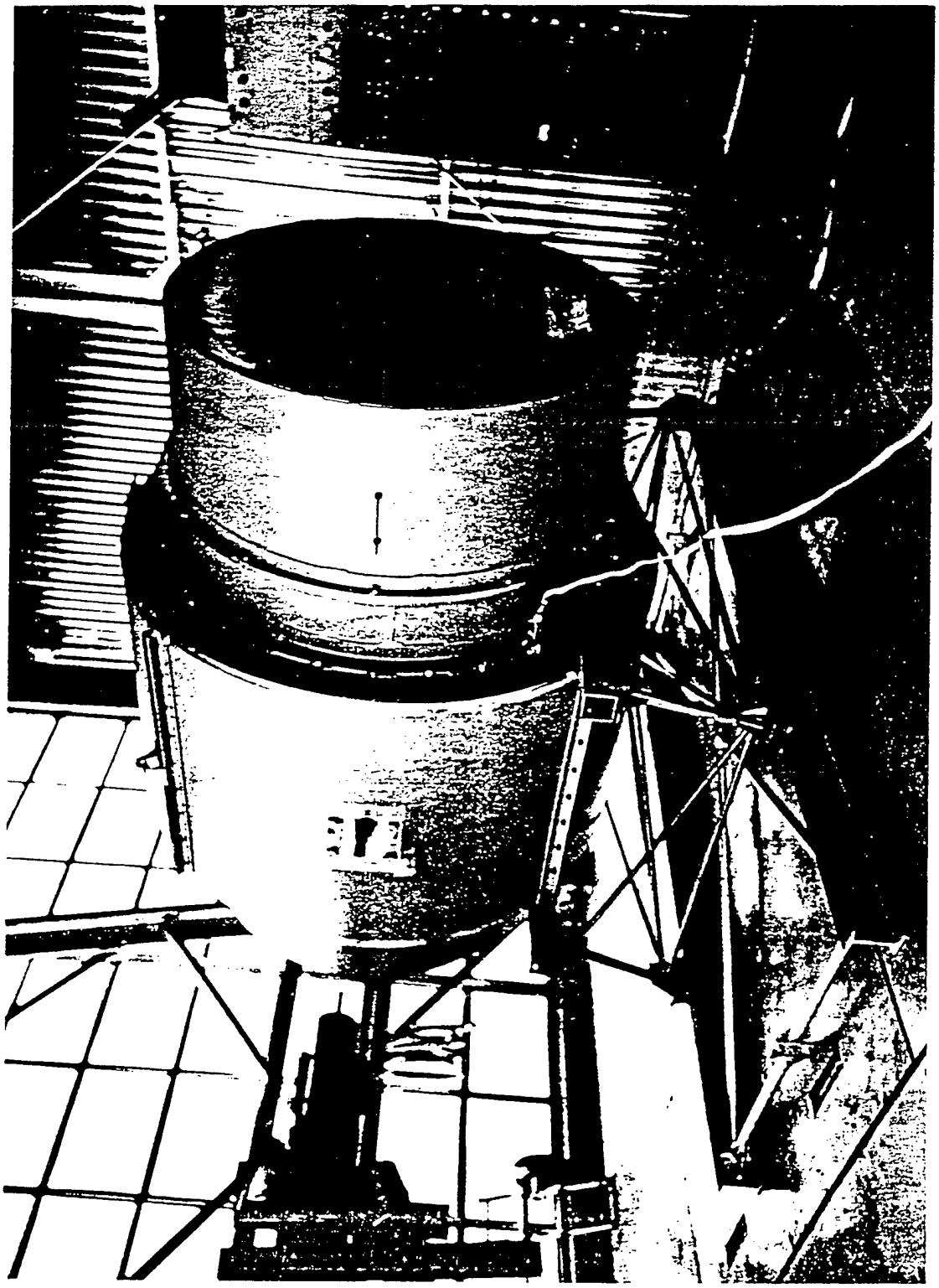

Fig. 3.37 Unit In Firing Position over Zero Point

Pages 94 through 100 are deleted.

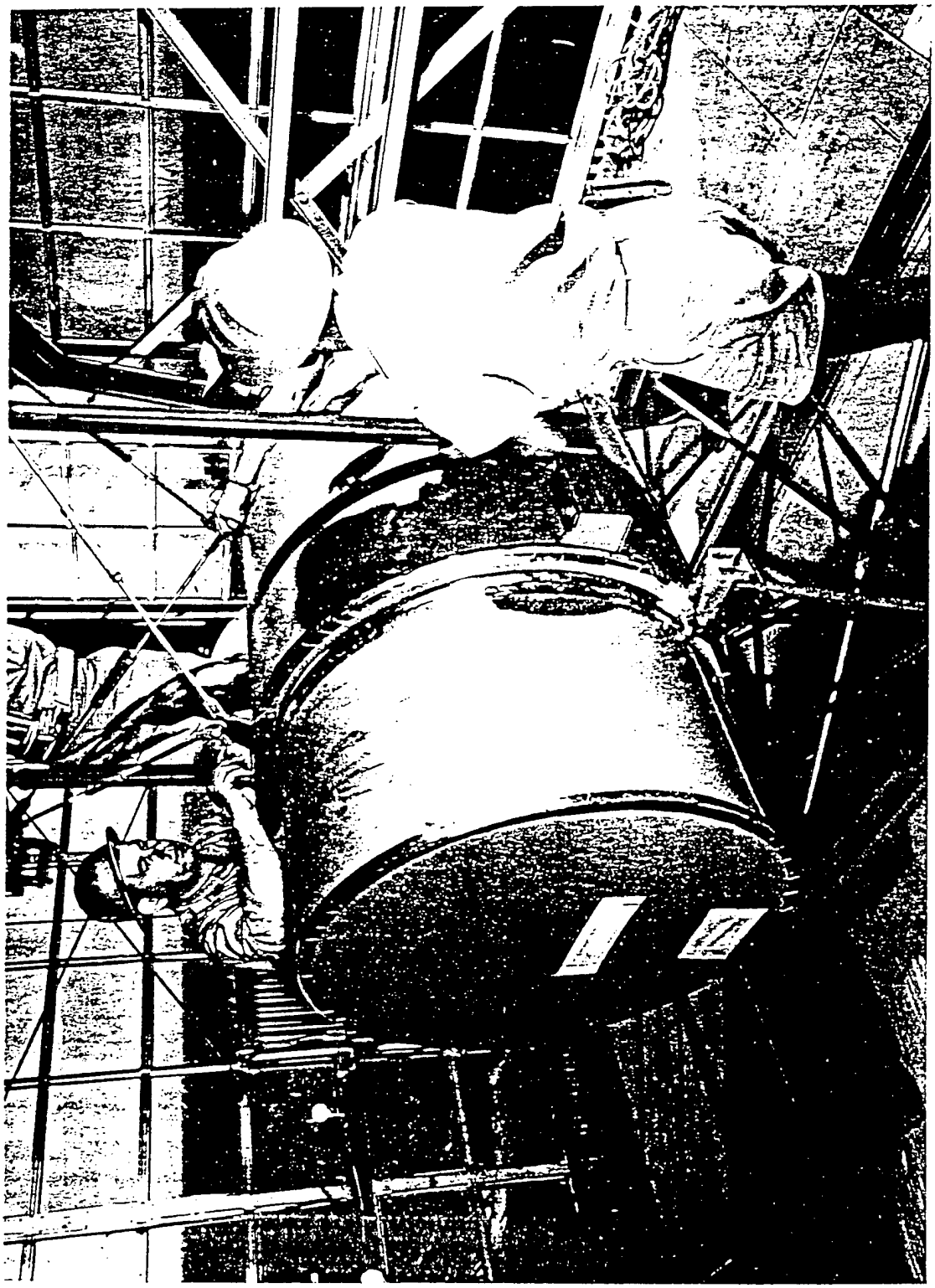

Fig. 3.45 [redacted] on Firing Stand

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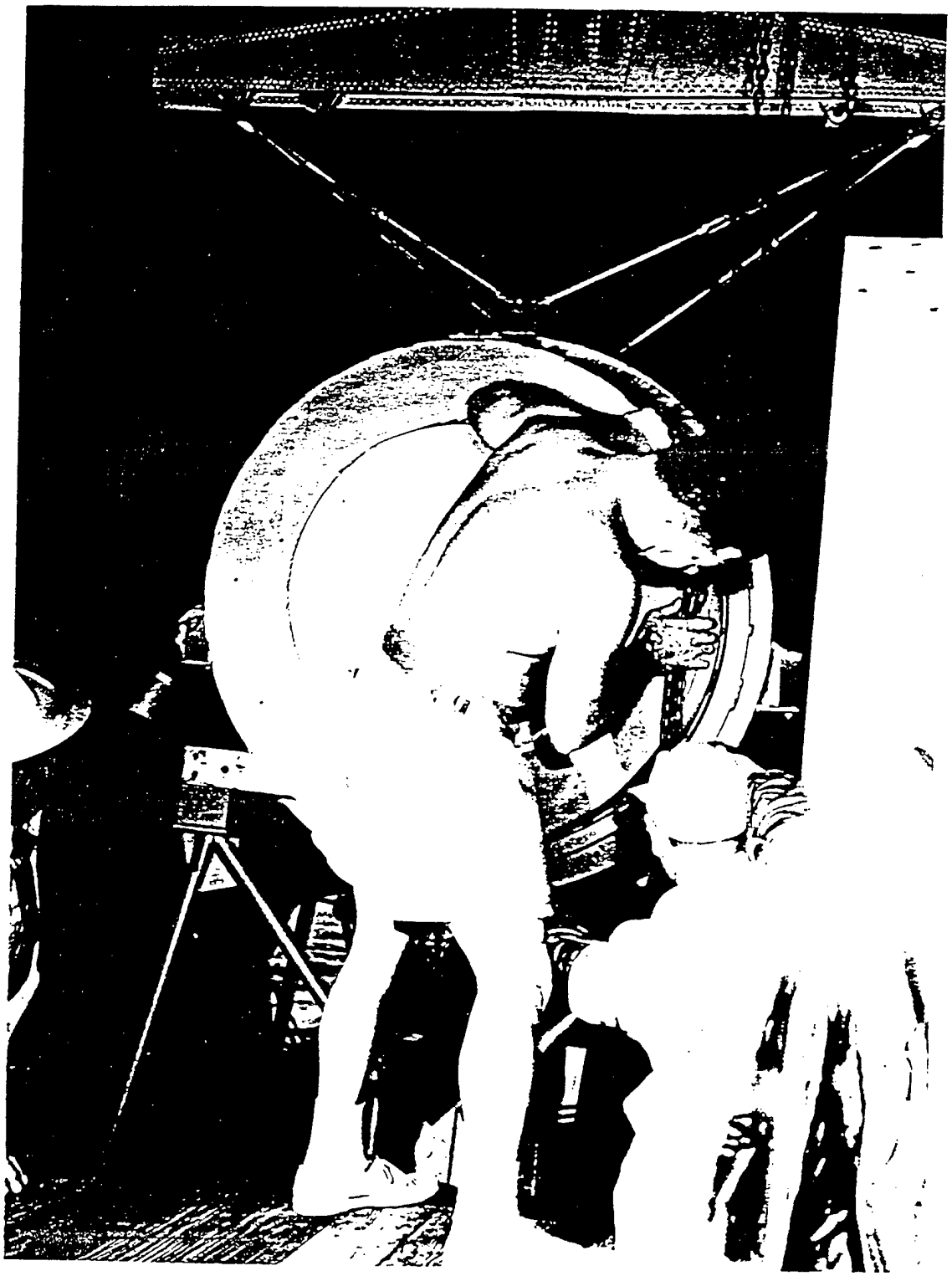

Fig. 3.48 Booster Being Positioned on Firing Stand

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